PB-215 927

CONFERENCE IN THE MATTER OF POLLUTION OF THE INTERSTATE WATERS OF THE COLORADO RIVER AND ITS TRIBUTARIES (6th) SESSION, DENVER LAW CENTER AUDITORIUM, DENVER, COLORADO, JULY 26, 1967. TRANSCRIPT OF PROCEEDINGS

Federal Water Pollution Control Administration
Washington, D. C.

26 July 1967

DISTRIBUTED BY:

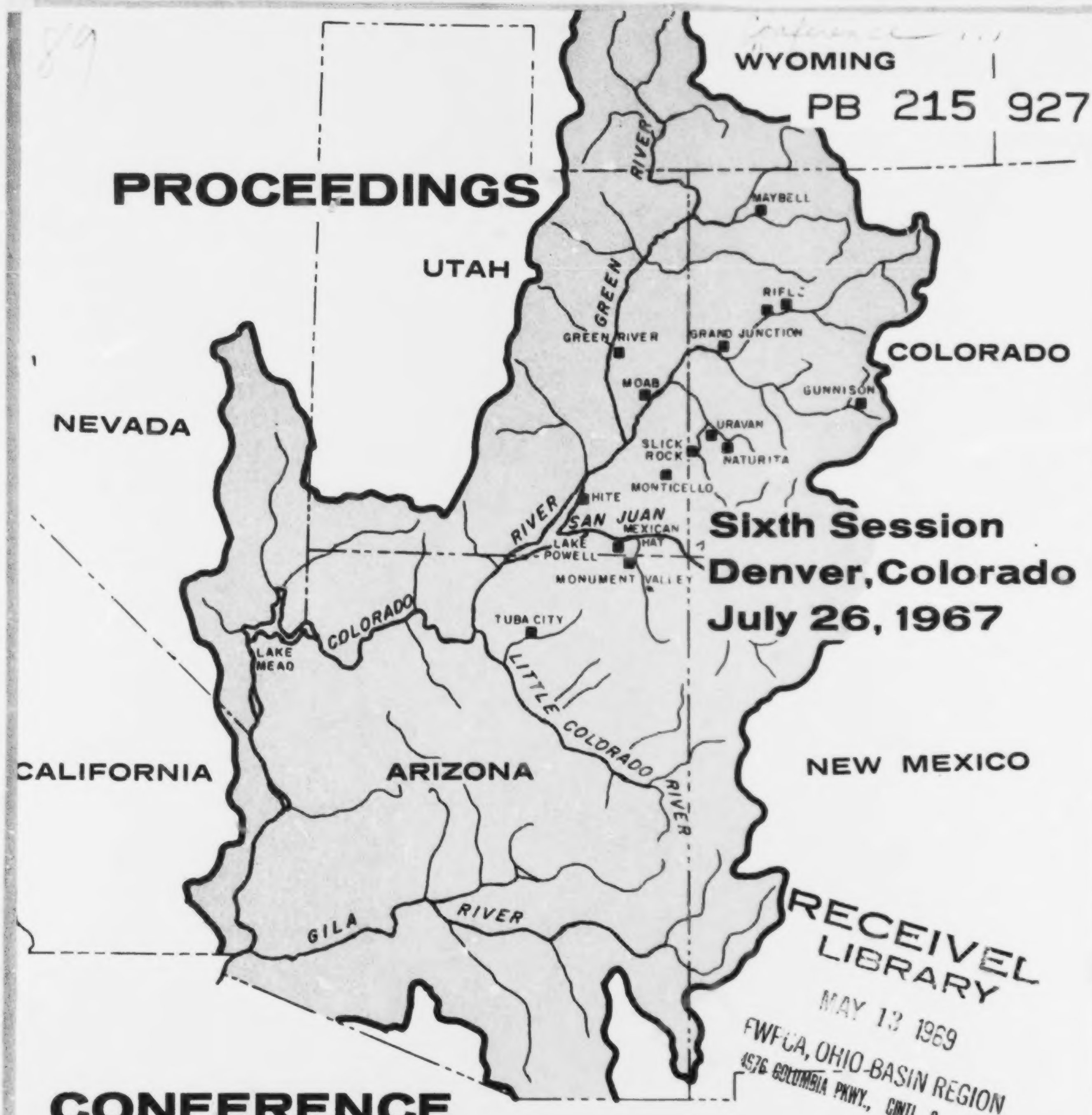
NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

89

Conference

PB 215 927

PROCEEDINGS


WYOMING
UTAH
NEVADA
COLORADO
CALIFORNIA
ARIZONA
NEW MEXICO
GREEN RIVER
MAYBELL
RIFLE
GRAND JUNCTION
GREEN RIVER
MOAB
GUNNISON
URAVAN
SLICK ROCK
NATURITA
MONTICELLO
HITE
SAN JUAN
MEXICAN HAT
LAKE POWELL
MONUMENT VALLEY
RIVER
COLORADO
LAKE MEAD
TUBA CITY
LITTLE COLORADO RIVER
GILA RIVER

Sixth Session
Denver, Colorado
July 26, 1967

RECEIVED
LIBRARY
MAY 13 1969
FWPCA, OHIO-BASIN REGION
4676 COLUMBIA PKWY., CINTI, O. 45226

CONFERENCE

Pollution of the Interstate Waters of the Colorado River and its Tributaries—Colorado, New Mexico, Arizona, California, Nevada, Wyoming, Utah.

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION • U. S. DEPARTMENT OF THE INTERIOR

217

/

CONFERENCE

in the matter of

Pollution of the Interstate Waters of the
Colorado River and Its Tributaries

TRANSCRIPT OF PROCEEDINGS

July 26, 1967

Details of illustrations in
this document may be better
studied on microfiche.

SIXTH SESSION

Denver Law Center Auditorium
200 West 14th Avenue
Denver, Colorado

U. S. Department of the Interior, FWPCA
Washington, D. C.

INDEX

Opening Statement by Murray Stein, Conference Chairman..... 3

Statements by Representatives of Federal Agencies:

Introductions by W. B. Schreeder, Federal Conferee....................................... 10

Dr. Ernest Tsivoglou, FWPCA........................... 12

Francis Mayo, FWPCA................................... 23

Kaarlo W. Nasi, PHS................................... 34

Donald I. Walker, AEC................................. 43

Statements by State Conferees and Other State Interests:

Howard V. Lewis, Colorado Conferee.................... 54

Fred Matter, Colorado................................. 55

P. W. Jacoe, Colorado................................. 62

Lynn M. Thatcher, Utah Conferee....................... 79

Wilfred C. Gilbert, Arizona Conferee.................. 88

John R. Wright, New Mexico Conferee................... 92

Arthur E. Williamson, Wyoming Conferee................ 96

Wallace W. White, Nevada Conferee.....................100

Paul R. Bonderson, California Conferee................102

Recommendations and Conclusions of Conferees..............105

Conference in the Matter of Pollution of the Interstate Waters of the Colorado River and Its Tributaries convened at 9:30 a.m., Wednesday, July 26, 1967, at the Denver Law Center Auditorium, 200 West 14th Avenue, Denver, Colorado.

PRESIDING:

Murray Stein
Assistant Commissioner for Enforcement
Federal Water Pollution Control Administration
Department of the Interior
Washington, D. C.

CONFEREES:

Paul R. Bonderson
Executive Officer
State Water Quality Control Board
2115 J Street
Sacramento, California 95816

Wilfred C. Gilbert
Arizona Atomic Energy Commission
40 E. Thomas Road
Phoenix, Arizona

Howard V. Lewis
Colorado Water Pollution Control Commission
4210 East 11th Avenue
Denver, Colorado 80220

Lynn M. Thatcher
Executive Secretary
Utah Water Pollution Control Committee
44 Medical Drive
Salt Lake City, Utah

Wallace W. White
Nevada Department of Health and Welfare
790 Sutro Street
Reno, Nevada 89502

CONFEREES (continued):

Arthur E. Williamson
Director, Division of Sanitary Engineering
Wyoming Department of Public Health
State Office Building
Cheyenne, Wyoming

John R. Wright, P.E.
Chief of Water & Liquid Wastes Division
New Mexico Department of Public Health
408 Galisteo Street
Santa Fe, New Mexico 87501

W. B. Schreeder
Regional Director
Southwest Region
Federal Water Pollution Control Administration
100 McCallister Street, Room 1219
San Francisco, California 94102

IN ATTENDANCE:

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

James E. Arden, Sanitary Engineer
Colorado River Basin Water Quality Control Project
Building 22, Room 415, Federal Center
Denver, Colorado 80225

William C. Blackman, Jr.
Chief, Phoenix Field Station
Colorado River Basin Water Quality Control Project
6122 N. 7th Street
Phoenix, Arizona

Garry L. Fisk, Deputy Regional Director
Federal Water Pollution Control Administration
Missouri Basin Region
601 East 12th Street
Kansas City, Missouri

Russell Freeman, Sanitary Engineer
Colorado River Basin Water Quality Control Project
Building 22, Room 415, Federal Center
Denver, Colorado 80225

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION (continued)

Roger E. Frenette, Civil Engineer
Colorado River Basin Water Quality Control Project
Building 22, Room 415, Federal Center
Denver, Colorado 80225

Milton W. Lammering, Sanitary Engineer
Federal Water Pollution Control Administration
Technical Advisory & Investigations Division
5555 Ridge Road
Cincinnati, Ohio

Francis T. Mayo
Enforcement Program Director
Federal Water Pollution Control Administration
Southwest Region
100 McAllister Street, Room 1219
San Francisco, California 94102

A. E. Metzler
Administrative Officer
Colorado River Basin Water Quality Control Project
Building 22, Room 415, Federal Center
Denver, Colorado 80225

Jim V. Rouse
Assistant Chief, Field Station
Colorado River Basin Water Quality Control Project
Phoenix Field Station
6122 N. 7th Street
Phoenix, Arizona 85014

D. E. Rushing, Director
Water Quality Control Laboratory
1750 S. Redwood Road
Salt Lake City, Utah

David Shedroff
Federal Water Pollution Control Administration
Southeast Region
1421 Peachtree Street N.E.
Atlanta, Georgia

Richard Sotiros, Civil Engineer
Colorado River Basin Water Quality Control Project
Building 22, Room 415
Denver, Colorado 80225

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION (continued)

Edmund J. Struzeski, Jr.
Deputy Project Director
South Platte River Basin Project
Federal Water Pollution Control Administration
Missouri Basin Region
Federal Office Building
Denver, Colorado

Ernest C. Tsivoglou, Consultant to
Federal Water Pollution Control Administration
1974 Starfire Drive, N.E.
Atlanta, Georgia 30329

David G. Welch
Physical Science Administrator
Colorado River Basin Water Quality Control Project
Building 22, Denver Federal Center
Denver, Colorado 80225

FEDERAL AGENCIES

Glen D. Brown, Senior Radiation Specialist
Atomic Energy Commission
10395 West Colfax
Denver, Colorado 80215

John E. Carver, Area General Engineer
Bureau of Indian Affairs
Albuquerque Area Office
Albuquerque, New Mexico

Lewis Chichester, Mineral Specialist
Bureau of Land Management
Building 50, Denver Federal Center
Denver, Colorado 80225

James M. Cox, Chief Sanitarian
Navajo Indian Health Area
Department of Health, Education & Welfare
United States Public Health Service
P. O. Box 188
Window Rock, Arizona

FEDERAL AGENCIES (continued)

John F. Douglas
United States Forest Service
Building 85, Denver Federal Center
Denver, Colorado 80225

Leo J. Dymerski, Regional Representative
National Center for Radiological Health
United States Public Health Service
Federal Office Building
Denver, Colorado

W. J. Frederick, Soil Conservationist
Soil Conservation Service
United States Department of Agriculture
12417 Federal Office Building
Denver, Colorado 80202

Albert P. Gildea, Assistant Chief
Design Branch
United States Army Corps of Engineers
300 North Los Angeles Street
Los Angeles, California

Croswell Henderson, Fishery Biologist
Bureau of Sport Fisheries & Wildlife
Room 101 Old Main Annex
Colorado State University
Fort Collins, Colorado

John L. S. Hickey, Assistant Chief
Environmental Surveillance & Control Program
United States Public Health Service
Department of Health, Education & Welfare
1901 Chapman Avenue
Rockville, Maryland 20852

Palmer King, Regional Solicitor
United States Department of the Interior
Building 57, Denver Federal Center
Denver, Colorado 80225

Harris R. McDonald, Hydraulic Engineer
Chief Engineer's Office
Bureau of Reclamation
Building 67, Denver Federal Center
Denver, Colorado 80225

FEDERAL AGENCIES (continued)

Frank E. McGinley, Branch Chief
CP&S Branch, SMP
Atomic Energy Commission
Grand Junction, Colorado

E. Rex Naanes, Chief
Branch of Water Inventories & Pollution Control
Region 4, United States Forest Service
324 25th Street
Ogden, Utah

Kaarlo W. Nasi, Associate Regional Health Director
United States Public Health Service
Department of Health, Education & Welfare
Region VIII
Federal Office Building
Denver, Colorado 80202

Clifford E. Nelson, M.D.
Regional Representative
National Center for Radiological Health
United States Public Health Service
50 Fulton Street
San Francisco, California 94102

Earl V. Porter, Regional Representative
National Center for Air Pollution Control
Federal Office Building
Denver, Colorado 80202

Dr. S. David Shearer, Chief
Technical Services
Southwestern Radiological Health Laboratory
United States Public Health Service
Box 684
Las Vegas, Nevada

Albert V. Soukup, Regional Program Chief
Water Supply Program
United States Public Health Service
9017 Federal Office Building
Denver, Colorado 80202

FEDERAL AGENCIES (continued)

Harvey F. Soule, Waste Management Engineer
Division of Operational Safety
Atomic Energy Commission
Washington, D. C.

J. N. Van Sant, Chief
Mineral Resource Office, Area V
United States Bureau of Mines
Building 20, Denver Federal Center
Denver, Colorado 80225

Dr. Donald I. Walker
Atomic Energy Commission
10395 W. Colfax Avenue
Denver, Colorado 80215

Jerry A. Westbrook, Recreation Resource Specialist
Bureau of Outdoor Recreation
Building 41, Denver Federal Center
Denver, Colorado 80225

S. R. Wilson, Mining Engineer
United States Bureau of Mines
1600 East First South
Salt Lake City, Utah

R. G. Woods, Assistant Regional Forester
United States Forest Service
Region 3
Albuquerque, New Mexico

Don C. Young, Assistant Regional Solicitor
Regional Solicitor's Office
United States Department of the Interior
Denver Federal Center
Denver, Colorado 80225

INDUSTRY

Ernest Carlucci, Plant Metallurgist
Atlas Minerals
Moab, Utah

Daniel R. Hale, Assistant Division Attorney
Climax Uranium
P. O. Box 493
Climax, Colorado

INDUSTRY (continued)

Floyd H. Larrison, Jr.
Plant Superintendent
Union Carbide Corporation
UCCMMD, Box 305
Uravan, Colorado

Kent L. Olsen, Assistant to the President
Atlas Minerals
P. O. Box 488
Moab, Utah

Ralph M. Wilde, Radiation Safety Director
The Anaconda Company
P. O. Box 638
Grants, New Mexico

Alan A. Baker
Project Manager
Halliburton Company
818 Hawley Building
Wheeling, West Virginia

Craig Barnes
Holland & Hart
500 Equitable Building
Denver, Colorado

James W. Hammond
Division of Industrial Hygiene, Medical
Humble Oil & Refining Company
Box 2180
Houston, Texas 77001

Myron B. Holburt
Principal Engineer
Colorado River Board of California
909 S. Broadway
Los Angeles, California

Ed Paramore, Vice-President
Halliburton Company
3211 Southland
Dallas, Texas

Harold E. Pearson
Chief Chemist
Metropolitan Water District of Southern California
P. O. Box A
La Verne, California 91750

Miles P. Romney, Manager
Utah Mining Association
825 Kearns Building
Salt Lake City, Utah 84101

Kenneth L. Tharp
Assistant Manager
Metro/Public Affairs
Denver Chamber of Commerce
1301 Welton Street
Denver, Colorado 80204

Doris Wells
League of Women Voters
2882 S. Corona Street
Englewood, Colorado

Gary Widman,Professor of Law
University of Denver
College of Law
200 W. 14th Avenue
Denver, Colorado

Victor Wilkins
Uintah County Commissioner
Vernal, Utah

OTHER STATE REPRESENTATIVES

Keith S. Campbell
Water Pollution Control Division
Colorado State Health Department
Denver, Colorado

Maida J. Christner
Water Pollution Control Division
Colorado State Health Department
4210 E. 11th Avenue
Denver, Colorado

OTHER STATE REPRESENTATIVES (continued)

Rowene C. Danbom
Public Information Officer
Colorado Public Health Department
4210 E. 11th Avenue
Denver, Colorado

Dr. P. W. Jacoe
Chief, Radiological Health
Colorado Department of Public Health
4210 E. 11th Avenue
Denver, Colorado

Fred Matter, Public Health Engineer
Colorado Water Pollution Control Division
Colorado Department of Public Health
4210 E. 11th Avenue
Denver, Colorado

Richard J. Reece, Director
Division of Air Occupation & Radiation Hygiene
Colorado Department of Public Health
4210 E. 11th Avenue
Denver, Colorado

Robert D. Siek
Senior Radiological Health Specialist
Colorado Department of Public Health
4210 E. 11th Avenue
Denver, Colorado

Edwin B. Haycock
Planning Director
Utah Division of Water Resources
Utah Department of Public Health
435 State Capitol
Salt Lake City, Utah 84114

RADIO AND PRESS

Rob Armstrong, Reporter
KTLN Radio
Denver, Colorado

RADIO AND PRESS (continued)

Judith Brinberg
Staff Writer
Denver Post
650 15th Street
Denver, Colorado

Gordon G. Gauss
Associated Press
Denver, Colorado

Andy Kurtz
Managing Editor
Western Farm Life
P. O. Box 299
Denver, Colorado

- - -

CHAIRMAN STEIN: The conference is open.

The Sixth Session of the conference in the matter of pollution of the interstate waters of the Colorado River and its tributaries is being held under the provisions of the Federal Water Pollution Control Act.

The purpose of the conference is to bring together the State water pollution control agencies, representatives of the United States Department of the Interior, and other interested parties to review the existing situation, the progress which has been made, to lay a basis for future action by all parties concerned, and to give the States, localities, and industries an opportunity to take any indicated remedial action under State and local law.

We have had the conference procedure on the Colorado River for many years, and I think this is truly an excellent example of Federal-State cooperation, particularly with the subject of the conference today, that is control of uranium mill tailings. There has been in this industry considerable progress. This progress in no small part has been due to the discussions held in conferences of this type and the development of information, working together with the States and with the uranium mill industry.

The conference today will be concerned with the control of uranium mill tailings piles, but this should be put into perspective. The uranium milling industry, in cooperation with the States and the Federal agencies involved, has done a rather excellent job of controlling pollution from its effluents going into waters of the Colorado River Basin. The radioactive levels in the Colorado River Basin have been reduced from uranium mill effluents and they are at a very low level. I think the technical people will speak on the problem later, but the Public Health Service, as you know, puts out drinking water standards, and the radiation level in the raw water, even, in the Colorado River Basin is about one-third of that. So I think that this is a signal success.

Very often people ask what do you do in pollution control, and we always have the question at these meetings, where is the action? I think this is one of the areas where we have had action and have had a considerable amount of success. What is left, of course, is dealing with the uranium piles, and that will be taken up at this meeting.

We have been charged by a Senate committee with looking into this. The Public Works Committee of the Senate, which is the substantive committee of our agency, and its Subcommittee on Air and Water Pollution have had a hearing and considered this matter. The committee is headed by Senator Jennings Randolph of West Virginia, and head of the Air and Water Pollution Subcommittee is Senator Edmund Muskie of Maine, and here is what the committee has said:

"The committee urges the Federal Water

Pollution Control Administration to move expeditiously to establish responsibility for control of the tailings piles, and provide the committee with adequate assurance that any control measures applied will be sufficient to achieve the long-term protection of the health of the people who live within the area, or depend upon the use, of the Colorado River."

I think that direction from our substantive committee is fairly clear.

At the Fifth Session, that is the previous session of the conference, it was recommended that the Federal Water Pollution Control's project staff prepare a report on the radioactive wastes in the Basin, including a review and evaluation of the tailings piles. We do have a resident staff in Denver working on the Colorado River Basin. This report has been prepared, submitted to the Conferees representing the States, representatives of the Atomic Energy Commission, and the Public Health Service.

Now, from a geographical land area, this is the largest enforcement conference we have. We have one involving Lake Erie with five States, but we just don't have one involving as many as this. You can see by the number of the Conferees at the table, you can hardly tell the players without a scorecard here.

We are dealing with fourteen hundred miles of main stem of the Colorado River, sixty tributaries, seven

States, and at least three Federal agencies having a real vital interest in the problem, the U. S. Department of the Interior, the Atomic Energy Commission, and the Public Health Service.

This is a conference between the States and the Federal government. We at the table are the Conferees. The State of Arizona is represented by Mr. W. C. Gilbert; California is being represented by Mr. Paul Bonderson; Colorado by Mr. Howard Lewis; Nevada by Mr. Wallace White; New Mexico by Mr. J. R. Wright; Utah by Mr. Lynn Thatcher; Wyoming by Mr. Art Williamson.

Mr. William Schreeder has been designated as Conferee for the Federal government. He is Regional Director for this river basin.

My name is Murray Stein, and I am from headquarters of the U. S. Department of Interior in Washington, representing Secretary Udall.

While this is a conference between the State representatives and the U. S. Department of Interior, other people are invited to participate. Participation will be open to representatives and invitees of these agencies and such persons as inform us that they wish to present statements. However, only the designated Conferees are the official Conferees for the purpose of the conference.

A word about the procedure governing the conduct of the conference. The Conferees will be called upon to make statements. The Conferees in addition may call upon their invitees or participants to also make statements. And we may call on interested parties to make statements too.

At the conclusion of each statement, the Conferees will be given an opportunity to comment or ask questions. This procedure has proven effective in the past in developing a factual pattern and providing a basis for devising equitable solutions. There will not be any questions from the floor. If we permit that, we have a mass meeting and we may be here for much longer than we expect. But if you have anything pertinent to say, save it for the time you make your statement and you will be allowed to make a full statement. We just ask that you please try to keep your remarks relevant, and we leave the determination of that to you.

At the end of all discussions we will have a discussion among the Conferees. The thought, unless we change it, is that the Conferees will retire to an executive session. We will hopefully come up with conclusions and we will make the conclusions public after we reconvene at the end of the executive session.

Under the Federal law, the Secretary of Interior is required at the conclusion of the conference to prepare a summary of it, which will be sent to the Conferees.

These conclusions the Conferees reach at the end will be the summary. The Secretary is also required to make recommendations for remedial action if such recommendations are indicated.

In view of all the work that has gone on here in the Basin on these uranium mill piles, the report of the technical group that we have here, the activities of the States, and the requests of the Senate committee, I don't doubt that the Secretary will make recommendations. In the past when the Conferees have been unanimous, the Secretary has always adopted those recommendations. At least I am going to try to see if we can get that unanimity today. With seven States and the Federal government, this may be no mean trick, but I hope we can take this back to the Secretary, Secretary Udall, and have him adopt these as his recommendations.

We will make copies of the summary and transcript available to the official State agencies. We have found that for purposes of maintaining relationships within the States that people who wish to get copies of the transcript and the summary should do this through their State agencies rather than us.

I think one of the keys in pollution control is that the day-to-day operation of pollution control has to rest with the municipalities and industries and the State agencies and not with the Federal government, and I think if we try to maintain that policy that this will be productive.

A record and verbatim transcript of the conference is being made by Mrs. Virginia Rankin. We will have that published eventually; I think publication dates now run about four months. Also if you have any exhibits or any maps to put in, when the transcript is printed, everything will be in black and white. It would help if anyone using a visual aid will try to remember that your statement will appear in transcript form and avoid saying something "over there" or the spot "marked in red" if it is going to come out in black and white, because when someone reads the transcript your statement in the transcript will be relatively unintelligible. The people who are making the statements should come up to the lectern to deliver them.

After the Senate committee asked us to work on this problem in this department, the Federal agencies involving the Department of the Interior, the Atomic Energy Commission and the Public Health Service have worked out a joint statement. This will be put into the record by one of the Federal participants, but I do think that everyone should understand that as far as I know the Federal agencies have discussed this and there is considerable unanimity among these agencies.

With that we will call on Mr. Schreeder for the Federal presentation.

Mr. Schreeder.

MR. SCHREEDER: I would like first to introduce a few members of the Federal Water Pollution Control Administration who are here today.

Mr. Gary Fisk, Deputy Regional Director from the Missouri River Basin Region, Kansas City.

Mr. Marshall Rainey, Project Director for the Colorado River Water Control Project at Denver.

Dr. Ernest Tsivoglou, our Consultant, Professor of Sanitary Engineering at the Georgia Institute of Technology at Atlanta.

Mr. Francis Mayo, the Director for Regional Enforcement Program, Southwest Region, San Francisco.

Various Federal agencies have indicated that they are going to be here today. Rather than run through a roll call, could I ask the representatives of the Federal agencies to stand and introduce themselves, starting on my left, and at the same time indicate whether they wish to make a statement at this Federal presentation.

MR. HENDERSON: I am Croswell Henderson, Bureau of Sport Fisheries & Wildlife. I do not care to make a statement.

MR. COX: James M. Cox, Navajo Indian Health Area, Public Health Service. I do not wish to make a statement.

DR. WALKER: Donald I. Walker, U. S. Atomic Energy Commission, and I will have a statement to make.

MR. MC DONALD: I am Harris McDonald, Bureau of Reclamation, representing the Chief Engineer's Office in Region III in Boulder City and Region IV in Salt Lake City. I have no statement to present.

MR. GILDEA: Albert Gildea, representing Col. Norman Pehrson, District Engineer, Corps of Engineers, Los Angeles. No statement.

MR. DOUGLAS: John Douglas, U. S. Forest Service, Denver. No statement.

MR. CHICHESTER: Lewis Chichester, Bureau of Land Management, Denver. No statement.

MR. NAANES: Rex Naanes, Intermountain Region Forest Service. No statement.

MR. WOODS: Lowell Woods, Assistant Regional Forester, Albuquerque, U. S. Forest Service. No statement.

MR. VAN SANT: Joe VanSant, U. S. Bureau of Mines, Mineral Resource Office, Area V. No statement.

MR. WILSON: S. R. Wilson, U. S. Bureau of Mines, Salt Lake City. No statement.

MR. FREDERICK: Bill Frederick, Soil Conservation Service, Denver. No statement.

MR. NASI: I am Kaarlo Nasi, U. S. Public Health Service, Department of Health, Education and Welfare, Region VIII, Denver. And I will make a statement for the Public Health Service.

MR. CARVER: John Carver with the Bureau of Indian Affairs, Albuquerque Area Office. I have no statement to make.

DR. SHEARER: Dave Shearer, U. S. Public Health Service, National Center for Radiological Health, Las Vegas. I have no statement.

CHAIRMAN STEIN: By the way, your statements here are not irrevocable. If something comes up and you change your mind, you will be given the floor.

DR. NELSON: Clifford Nelson, Regional Representative, National Center for Radiological Health, Region IX, San Francisco. No statement.

MR. SCHREEDER: We would like to call first on Dr. Tsivoglou for his statement.

DR. TSIVOGLOU: Mr. Chairman, Conferees, ladies and gentlemen.

I have been requested to recapitulate briefly in regard to radiological pollution of surface waters of the Colorado River Basin from uranium milling and to outline the present status of the cooperative abatement program that was begun several years ago.

As you know, the major expansion of the uranium milling industry began in the late 1940's and production reached a peak in the late 1950's and the early 1960's. Some of the more extensive uranium ore deposits in the western part of the country are located in the Colorado River Basin, and several of the nation's larger uranium mills have been located within this Basin. Uranium ore has been processed at seventeen mill sites in the Basin, under production controls and licenses issued by the Atomic Energy Commission. At the peak of production these mills processed approximately one-third of the uranium ore produced in the United States, in the neighborhood of 6,600 tons per day of ore processed.

The mining phase of the industry generally produces no significant quantity of wastes that have water pollution potential. The extraction of uranium from the ore at the processing mills does result in substantial quantities of both liquid and solid wastes. These wastes contain significant amounts of radioactivity in the form of natural radioactive elements that are always associated with radium.

About 85 percent of the original radioactivity remains in the milling wastes. Most of this occurs in the solid wastes, or the tailings, which are usually piled near the milling site. A smaller portion of the radioactivity appears in the liquid wastes. The disposal of all or part of the solid and the liquid wastes in the nearby streams was a common practice in the mid-1950's. It resulted in the transfer of radioactivity to the stream environment and created other water pollution problems. For example, and this goes back a ways, this goes back to the middle 1950's, at one mill alone several hundred tons per day of tailings material were discharged into a nearby tributary of the Colorado River.

In the mid-1950's, at the request of several of the Basin States, the U. S. Public Health Service began collecting samples from streams and from uranium mill effluents to evaluate the extent and the significance of radioactive contamination of the stream environment. These initial studies demonstrated that radium, the most hazardous radioisotope involved, was present in the waters of several streams below uranium mills and in concentrations considerably above the amount generally regarded as acceptable or safe. In addition, extensive deposits of radium-bearing uranium mill tailings material were found along some of the stream beds.

On April 28, 1958, at the request of the New Mexico Department of Public Health, an enforcement conference was called under the provisions of Public Law 660 to obtain abatement of radioactive pollution of the Animas River, which flows from California into New Mexico. At the Animas Conference, the Conferees agreed that discharges of uranium wastes from the mill at Durango had deleterious effects on the water quality of the Animas River. When the extent and significance of the problem had been determined, the uranium mill involved began an effective pollution abatement program in cooperation with the State and Federal agencies concerned.

In 1960, at the request of six of the seven Colorado River Basin States, a conference was called regarding all types of water pollution in the entire Colorado River Basin. At that time the Colorado River Basin Water Quality Control Project was established. So far as radioactivity is concerned, the Project's initial work included further detailed studies of radiological water pollution problems associated with the uranium milling industry throughout the Basin, and routine radiological surveillance activities were also begun.

A Radium Monitoring Network, consisting of surface water sampling stations at key locations throughout the Colorado River system, was established in 1961. Samples collected routinely from the Network are analyzed for radium-226 and several other radionuclides to provide a broad picture of radioactive contamination of the surface waters, if any. Radium-226 proved to be a very extensive indicator of contamination by radium mill wastes.

The Radium Monitoring Network results provided an excellent picture of week-by-week and month-by-month changes in surface water radioactivity concentrations resulting from radium mill wastes. To supplement the data on current radioactivity levels in Basin streams and reservoirs, a periodic sediment sampling program was also implemented at key locations to provide information on the long-term accumulation of uranium mill tailings discharges. Both the Radium Monitoring Network and the sediment sampling program have been operated on a continuing basis up to the present time.

It is now a well-recognized basic principle that human radiation exposure should be reduced to the maximum extent that is technically feasible and economically reasonable. As data from the surveillance activities and other project studies accumulated, it became clear that uranium milling wastes were creating a radiological pollution problem in some of the Basin streams, and a program of pollution abatement was undertaken by the uranium milling industry in cooperation with State and Federal agencies. The industry instituted practices for retaining and managing the mill tailings material that had been found to be the major source of radioactive contamination in streams.

The project's surveillance activities have demonstrated that for all practical purposes, streams of the entire Basin have been essentially free of recent bottom deposits of mill tailings for the past several years. In earlier years mill operators were also plagued by breaks in tailings pond dikes which released large amounts of radioactive wastes into streams. Improved dike construction and maintenance has greatly reduced this problem. In addition, improved chemical treatment facilities were installed at some mills to removed dissolved radium from the liquid wastes.

This cooperative industry-government abatement program for the prevention and control of radiological pollution in the Colorado Basin has been highly successful. The Radium Monitoring Network results have demonstrated clearly that, with the exception of a very few transient instances, radioactivity levels in Basin streams have been substantially below recommended limits for the past several years. At most locations during recent years, the surface waters of the Basin have contained no more than one-third of the radium content regarded as acceptable.

We regard this as a precedent-setting case in which an entire industry has cooperated in reducing stream pollution well below the level that might be regarded as acceptable. We believe that the uranium milling industry deserves real credit for this excellent record of prevention and control of radiological pollution in streams below operating mill sites, and in particular for setting an example of minimizing environmental pollution in fact as well as in theory. We think this is an enviable example for other industries to emulate.

The decrease in demand for uranium after the early 1960's caused some companies to discontinue milling operations in the Colorado Basin. This situation raised questions regarding the long-term responsibility and control measures for the large piles of solid wastes or tailings located at the inactive mill sites. It is well known that much of the radioactivity contained in the tailings piles is very long-lived. For example, radium-226 has a half-life of 1,620 years, thorium-230 a half-life of about 80,000 years.

Field observations at tailings piles sites have shown that the tailings material may enter nearby streams by means of wind and water erosion. It has also been demonstrated that radioactivity contained in the tailings material is leached by water when the solids reach a stream. While slow erosion of tailings pile material into Basin streams will not produce large-scale or high-level contamination, the inactive piles do represent a substantial source of radioactivity that could reach the streams over a long period of time. It is the long-lived nature of the radioactivity, together with the potential for long-term continuing low-level contamination of Basin surface waters that we believe requires a conservative attitude regarding the disposition and control of uranium tailings.

By May of 1964, when the Fifth Session of the Colorado River Basin Conference was convened, uranium milling operations had been discontinued at several locations in the

Basin. Conferees were concerned about the potential water pollution hazards associated with the inactive tailings piles, particuarly those located immediately adjacent to streams. At this conference, the Colorado River Basin Water Quality Control Project was directed to prepare a detailed report on this problem. The Project's report, entitled "Disposition and Control of Uranium Mill Tailings Piles in the Colorado River Basin," was prepared and released in March of 1966.

At the time of release, copies of the report were submitted to the conference Conferees and to representatives of the U. S. Public Health Service and the U. S. Atomic Energy Commission. The report has also been distributed to representatives of the uranium industry, other State and Federal agencies, and numerous interested individuals.

There were detailed discussions concerning the report at the May 6, 1966, hearings on "The Problem of Radioactive Water Pollution in the Colorado River Basin" before the Subcommittee on Air and Water Pollution of the Committee on Public Works, United States Senate. The first 36 pages of the text of the report are included in the published record of those hearings.

In view of this, only a few highlights of the report will be mentioned here. The report provides detailed information on the nature and extent of the uranium mill tailings problem, the size and physical characteristics of individual tailings piles, the potential for long-term water contamination by erosion of the piles, and suggested control measures, together with estimates of their costs.

The tailings report also contained the following specific recommendations regarding the uranium mill tailings piles:

(1) That interim measures to prevent the erosion and spread of uranium mill tailings piles be undertaken without undue delay.

(2) That all distribution of mill tailings from either non-operating or operating mills be halted until proper and adequate precautionary review procedures can be instituted.

(3) That discussions be held and binding agreements be reached as soon as possible regarding long-term public and/or private responsibility for adequate maintenance of the tailings piles.

The first and third of these recommendations refer primarily to inactive tailings piles. As indicated in the report, implementation of interim control measures to prevent the spread of the tailings material for 10 to 20 years would provide a time period, it was felt, during which questions might be answered regarding the effects of river hydrology, the potential for human radiation exposure, responsibility for pile maintenance, and ultimate disposition and control requirements.

The interim measures for the control of wind and water erosion of tailings piles suggested in the report included retrieval of eroded tailings material, shaping and grading of piles, earth retaining dikes with rock riprap where necessary, and covering of piles with earth or other protective material. The estimated costs for carrying out the suggested control measures were regarded as reasonable.

In summary, I would like to emphasize again that the pollution control measures employed by the uranium industry at the operating mills have been very effective in reducing radioactivity in Basin streams to levels below recommended limits, and there is currently no significant immediate radiological hazard associated with discharges of uranium milling wastes in the Basin. On the other hand, uranium mill tailings piles that are subject to wind and water erosion do constitute a long-term potential water pollution threat, and action, we believe, should be taken without undue delay to protect the tailings piles against such erosion.

I understand that during the past year or two several of the uranium milling companies have developed plans and some have begun activities with the object of preventing wind and water erosion of the tailings piles, and that the State of Colorado has promulgated regulations requiring such control measures. The details of these most recent activities will be discussed by subsequent speakers.

Thank you. That ends my statement.

CHAIRMAN STEIN: Thank you, Dr. Tsivoglou.

Are there any comments or questions?

I would like to commend you for an excellent statement. Dr. Tsivoglou has been in this situation from the very beginning, as a matter of fact the very beginning, and has done yeoman work in the control of radiation in the Colorado River Basin. I think in large measure the factual basis and the impetus for the cooperative program has come from Dr. Tsivoglou's work. He used to do the work as an engineer. Now he is a professor, Professor of Sanitary Engineering.

DR. TSIVOGLOU: I am a little bit concerned about the coming football season.

CHAIRMAN STEIN: He is now with Georgia Tech., and they have scheduled Notre Dame to play for the next season.

Another thing, do you know where Georgia Tech. plays its football games? Grant's Stadium, of all places. (Laughter.)

Thank you very much, Dr. Tsivoglou.

Mr. Schreeder.

MR. SCHREEDER: Thank you, Ernie.

I would like to ask Mr. Mayo to present a statement for the Water Pollution Control Administration.

MR. MAYO: Mr. Chairman, Conferees, ladies and gentlemen.

Federal and State water pollution control agencies have been concerned about radiological pollution in the Colorado River Basin for more than a decade. At the First Session of the Colorado River Basin Conference held in 1960 the Conferees emphasized the need for control of radiological pollution problems associated with the uranium milling industry in the Basin. During the early 1960's a comprehensive program of radiological water pollution abatement was undertaken by the uranium milling industry in cooperation with State and Federal agencies. As Dr. Tsivoglou has already indicated, this pollution control program, consisting of containment and treatment of uranium wastes at the operating mills, has been highly effective in reducing radioactive discharges into Basin streams. The current radioactivity levels in surface waters of the Basin are substantially below recommended limits. The uranium industry is to be commended for the very successful program of radiological pollution control at their operating uranium mills.

The disposition and control of inactive uranium mill tailings piles has been a problem of major concern to State and Federal water pollution control agencies during the past several years. Detailed studies of the water and air pollution aspects of uranium mill tailings piles have been undertaken by the Federal Water Pollution Control Administration and the U. S. Public Health Service in cooperation with the States. The Atomic Energy Commission has also conducted studies of several tailings piles in the Colorado River Basin, including the pile at Monticello, Utah, where in 1962 the Commission carried out an extensive control program consisting of reshaping, earth covering and seeding of the pile. Additional studies have been made by State organizations in cooperation with Federal agencies.

The Colorado River Basin Water Quality Control Project Report entitled "Disposition and Control of Uranium Mill Tailings Piles in the Colorado River Basin" was prepared at the request of the Conferees and released in March of 1966. At the time this report was released, uranium milling operations had been discontinued at ten of the seventeen mill sites in the Basin. Tailings piles were located at each of the ten inactive mill sites as well as at seven active sites. In addition, there were inactive piles at the operating mill at Uravan, Colorado. Thus, there were inactive tailings piles at eleven different locations in the Basin, all of which were in Colorado and Utah.

In Colorado the piles were located at the Rifle, Maybell, Gunnison, Durango, Slick Rock, Naturita, and Uravan milling sites. The four inactive piles in Utah were at the Mexican Hat, Monticello, Hite and Green River mill sites. The AEC pile at Monticello, Utah, was the only one of the eleven inactive piles that at that time had been covered and protected against water and wind erosion. The pile at Hite, Utah, had been inundated by Lake Powell after removal of a portion that contained higher uranium values.

Of the nine unprotected inactive piles remaining in early 1966, seven were in Colorado and two were in Utah. At the time of the report, there were seven active piles. Two were located in Arizona at Tuba City and Monument Valley, one in New Mexico at Shiprock, three in Colorado at Grand Junction, Rifle and Uravan, and one in Utah at Moab.

The United States Senate Subcommittee on Air and Water Pollution of the Committee on Public Works held a hearing on uranium tailings piles in the Colorado River Basin on May 6, 1966. The position and views of the Federal Water Pollution Control Administration, the Atomic Energy Commission, the State of Colorado, and other parties interested in the disposition and control of uranium tailings piles were presented at this hearing. After the hearing the Senate Subcommittee on Air and Water Pollution urged the interested Federal agencies to move expeditiously to solve the problem of providing for adequate control of the tailings piles.

In the fall of 1966 discussions were initiated between representatives of the FWPCA, PHS, and AEC to reach agreement on the position of these agencies with regard to the disposition and control of uranium mill tailings piles. On December 8, 1966, representatives of the Department of Interior, Department of Health, Education and Welfare, and Atomic Energy Commission signed a document entitled "Joint Federal Agency Position Regarding Control of Uranium Mill Tailings", which reads as follows:

"The Federal Water Pollution Control Administration, the Public Health Service, and the Atomic Energy Commission agree that inactive tailings piles resulting from uranium milling operations should be structurally stabilized and contained to prevent water and wind erosion. Active tailings piles should be managed to minimize such erosion during use.

"Planning, management, stabilization and containment of tailings piles are viewed as being the responsibility of the individual mill owners. Mill owners should develop, without undue delay, specific plans for accomplishing such management, stabilization and containment, and submit such plans through the appropriate State regulatory agencies for approval. The staffs of the Federal Water Pollution Control Administration, the Public Health Service, and the Atomic Energy Commission will be available to the State regulatory agencies, upon request, to provide advice and assistance regarding the development of pile stabilization and containment objectives and measures for achieving them.

"Compliance by mill owners with approved plans for stabilization and containment should be recognized as constituting fulfillment of mill owner responsibility with regard to such tailings piles. Obtaining and enforcement of tailings piles stabilization and containment plans should rest initially with the States concerned."

A regulation requiring that tailings piles from uranium and thorium mills be adequately stabilized or removed was adopted by the Colorado State Board of Health in May 1966. In December 1966 the Colorado State Board of Health adopted Radiation Regulation No. 2, entitled "Requiring Stabilization of Uranium and Thorium Mill Tailings Piles," which supplements the State's first regulation and outlines the measures to be employed in stabilizing uranium and thorium mill tailings piles. The Colorado State Board of Health is to be commended for taking the leadership in implementing a formal program for the stabilization of uranium and thorium mill tailings piles.

Colorado is the only one of the Colorado River Basin States that has developed a formal program for the stabilization of uranium mill tailings piles. The States of Utah, Arizona and New Mexico appear to be moving in that direction. In view of this, it is hoped that the Colorado experience with regulations and other aspects of the control program will be presented in some detail at this conference. It is believed that this will be of mutual benefit to all of those who are concerned with the tailings pile problem in other parts of the Colorado River Basin.

The uranium milling companies carried out some control work at several of the piles during 1966 and 1967. Much of the corrective work accomplished by industry has been conducted on a voluntary basis and is deserving of recognition. The earlier work accomplished by AEC at Monticello has served as an important guide in the development of stabilization programs by industry. It is hoped that industry's experience on pile stabilization work to date and their future plans for stabilizing each pile will be presented in some detail here today.

In the past there have been a number of issues that served to delay the implementation of active control programs for protecting uranium mill tailings piles against wind and water erosion. We feel that most of these issues have now been clarified. It is therefore hoped that at this conference the Conferees can reach agreement on at least the following points concerning the disposition and control of uranium mill tailings piles in the Colorado River Basin:

(1) The inactive tailings piles should be

contained and structurally stabilized to prevent wind and water erosion. Active tailings piles should be managed to minimize such erosion during use.

(2) The planning, management, and containment of the piles is the responsibility of the individual owners.

(3) The primary responsibility for securing and enforcing the necessary stabilization and containment of uranium mill tailings piles rests with the States concerned.

(4) The establishment of a basic target date for completion of necessary corrective measures to prevent wind and water erosion at active and inactive piles in the Colorado River Basin.

(5) Reasonably uniform State requirements and implementation programs for the control of tailings piles are desirable in the Colorado River Basin.

(6) The surveillance activities customarily performed by the State and Federal agencies should be continued for purposes of providing a continuing evaluation of the adequacy of control measures in terms of the transient and long-term environmental radioactivity levels.

That is the end of my statement, Mr. Chairman.

CHAIRMAN STEIN: Thank you, Mr. Mayo.

Are there any comments or questions?

I would like clarification on this. I think the record may need this. You talk in terms of inactive tailing piles should be contained and structurally stabilized to prevent wind and water erosion. In the work of the various groups do you believe that there are reasonable alternatives available so that the piles can be structurally stabilized and this can be done?

MR. MAYO: Yes. The FWPCA report indicated several of the alternatives.

CHAIRMAN STEIN: Do you want to outline or just go through the list of alternatives?

MY. MAYO: These alternatives might extend from actual covering by earthen materials to spraying with petroleum products in order to control the very surface of the pile and prevent water and wind erosion, the possible laying of asphaltic materials over the pile, the riprapping of the sides of the piles to prevent bank erosion where the piles are close to streams or water courses. These are the sorts of alternatives that were reviewed and considered and commented upon in the report.

CHAIRMAN STEIN: Do you think that it is possible to manage active piles to minimize erosion during use?

MR. MAYO: Yes. As long as we are talking about the control of wind and water erosion, the Project feels that there are reasonable alternatives to control the side slopes from erosion and for controlling the surfaces of the pile to prevent wind erosion.

CHAIRMAN STEIN: Would you like to give an example?

MR. MAYO: The side slopes could be contained by earthen embankment covers, rock riprap covers, alternative materials that would keep the banks from sloughing, the maintenance of reasonable angles of repose on the sides of the piles.

The active piles generally are wet on top, a good portion of them are wet. These aren't going to blow. Frequently portions of the tops of the active piles are dried out and here it would be a rather simple problem of perhaps sprinkling to minimize wind erosion.

CHAIRMAN STEIN: All right. Now, you mentioned the work by AEC at the Monticello pile. What did they do, sod?

MR. MAYO: The pile was completely covered with earth, it was reshaped, leveled in part, completely covered with earth, seeded with the establishment of a vegatative cover.

CHAIRMAN STEIN: Has that been successful?

MR. MAYO: From all appearances, the work has been particularly successful.

CHAIRMAN STEIN: In other words, I gather from you there are reasonable alternatives to stabilize, structurally stabilize, the inactive piles, to manage the active piles, and, in fact, at Monticello this has been done and has proved to be eminently successful.

MR. MAYO: Yes, the substance of the report was that the recommendations being made were physically practical and economically acceptable.

CHAIRMAN STEIN: Are there any further questions?

Mr. Schreeder.

MR. SCHREEDER: Mr. Mayo, there may be some people in the audience who don't know what a uranium mill tailings pile looks like, and they may be a little bit curious as to why we are so interested in preventing wind and water erosion. Would you take a minute and describe the physical characteristics of a tailings pile and what happens to it if you have a high wind?

MR. MAYO: Well, the piles represent an accumulation of milling wastes at the mill site. The wastes range in character from the coarseness of perhaps a coarse sand down to very fine materials that are referred to by the industry as slimes. The waste materials are accumulated in what are called piles adjacent to the mill site.

Typically the waste material is distributed as a slurry behind an earthen dike embankment, and as the level of the pile increases in size, the dike will be raised and the tailings material controlled within the boundaries of the dike. The piles can reach fairly significant heights, on occasion perhaps 30 or 40 feet.

At the inactive sites as the water content of the tailings material is evaporated away, the surface of the pile becomes dry, and depending on the character of the material that is deposited and the local conditions at the site, the pile can be subject to significant wind erosion, which would carry the radioactive waste materials at times fairly considerable distances from the pile. At some locations the piles are located adjacent to streams in the Colorado River Basin, some of the piles right at the stream bank, and the piles can be subject to erosion from spring flood flows or at times from the typical cloudburst storms that occur in the southwest part of the United States, and it is the close proximity of some of the piles to water courses and their susceptibility to wind erosion that are important factors in the desirability for having them stabilized and controlled to prevent both wind and water erosion.

CHAIRMAN STEIN: Thank you.

Are there any further comments or questions?

If not, thank you very much.

Lynn, you see, we have the best of both possible worlds, a Brooklyn boy trained in Utah. (Laughter.)

At this point I think we will recess for ten minutes.

(Recess)

CHAIRMAN STEIN: May we reconvene.

We will continue with the Federal presentation. Mr. Schreeder?

MR. SCHREEDER: Mr. Chairman, the previous speaker mentioned the March 1966 report entitled "Disposition and Control of Uranium Mill Tailings Piles in the Colorado River Basin." With your permission, I would like to have this report included in the conference proceedings as an appendix.

CHAIRMAN STEIN: We will include this as an appendix, if there is no objection. (See Appendix A.)

I hear none. It will be included as an appendix.

Mr. Schreeder, would you continue.

MR. SCHREEDER: I would like to call on Mr. Kaarlo Nasi, the Associate Regional Health Director for the Public Health Service, for his statement.

MR. NASI: Bill, I wonder if I might, with your permission and with the permission of the gentlemen at the head table, introduce a few Public Health Service representatives, key representatives, who are also here who refrained from introducing themselves. If that is all right, I will do that at this time. I think I have got these people in alphabetical order rather than in the order of organizational status.

Mr. Leo J. Dymerski is our Regional Representative for the National Center for Radiological Health, Region VIII, Denver, Colorado. Mr. Dymerski.

And Mr. John L. S. Hickey, who is the Deputy Chief, Protective Action Section, Environmental Surveillance and Control for the National Center for Radiological Health, from our headquarters of that center at Rockville, Maryland. Mr. Hickey.

And Dr. Nelson of San Francisco has introduced himself.

I would like to also introduce Mr. Earl V. Porter. Mr. Porter is the Regional Representative for our National Center for Air Pollution Control in Region VIII, Denver. Thank you.

Dr. Shearer has introduced himself.

Next and last I would like to introduce Mr. Albert V. Soukup, who is the Regional Program Chief, Water Supply and Sea Resources Program of our National Center for Urban and Industrial Health, and he is located here in Region VIII, Denver.

Are there any other Public Health Service representatives of the Department of HEW who have not introduced themselves?

Mr. Chairman, Mr. Schreeder, and State Conferees. We appreciate this opportunity to participate in this Sixth Session of the conference in the Matter of the Pollution of the Interstate Waters of the Colorado River. Several offices of the Public Health Service have received invitations to attend and to give statements. However, this single statement has been prepared which I will present in behalf of all of the Public Health Service representatives. I should note, as I have already introduced several, that the representatives of the other offices of the Public Health Service, both field and headquarters, are present here today.

Much organizational change has taken place since the last meeting of the conference in May 1964. At that session and at previous ones, as has been mentioned, the chairman and the Federal Conferees were representatives of the Public Health Service. However, Congressional and Presidential actions have since effected the transfer of the Service's Division of Water Supply and Pollution Control, first out of the Public Health Service to become a separate agency in our department, and later to its present status as the Federal Water Pollution Control Administration in the Department of Interior. Consequently, I appear today, so to speak, on the other side of the table, representing the Service as one of several other Federal agencies having some interest and responsibility relating to the matters under discussion.

I would first like to mention briefly the continuing responsibilities of the Public Health Service in the health aspects of water pollution control and then to review very briefly its present interests and activities relating to the control and disposition of uranium mill tailings piles.

The 1965 amendments to the Federal Water Pollution Control Act, which created the Federal Water Pollution Control Administration, included an amendment, Section 2(k), requiring the head of the Administration to consult with the Surgeon General on the public health aspects of water pollution control. Implementing this section, and complying with President Johnson's Reorganization Plan No. 2 of 1966, an interdepartmental agreement concerning consultation between the Departments of HEW and Interior, signed by President Johnson on September 1, 1966, outlined the respective responsibilities of the two Departments. Specific programs identified for DHEW included technical assistance participation in enforcement proceedings such as this one, involving health aspects of water pollution control. I should note that organizationally this responsibility of the Public Health Service has been assigned to the Water Supply and Sea Resources Program of the National Center for Urban and Industrial Health.

The Public Health Service also continued to provide technical assistance and to carry out studies on health problems related to such specific areas as uranium mining and milling and waste disposal. These activities, conducted under the Service's basic responsibility to protect and advance the health of the American people, are carried out mostly by the National Center for Radiological Health and the Occupational Health Program of the National Center for Urban and Industrial Health. The Solid Wastes program of the National Center for Urban and Industrial Health, recently organized to implement the Solid Wastes Disposal Act of 1965, may also relate to this subject.

With specific reference to uranium mill tailings piles, the position of the Public Health Service has been recently stated in the "Joint Federal Agency Position Regarding Control of Uranium Mill Tailings." This was discussed earlier in this session by Mr. Mayo.

Our objective, the Public Health Service objective, is the containment of existing piles and future radioactive wastes from mills in a manner which is satisfactory from a health viewpoint. Our plan of action is aimed principally toward providing assistance to States in developing uniform methods for evaluating environmental radiation levels due to the piles, for developing guides and recommendations on suitable containment methods, and determining how they should be monitored afterward to measure the effectiveness of containment.

The Public Health Service has been coordinating its efforts with the Atomic Energy Commission, and where streams are involved, will also work with the Federal Water Pollution Control Administration in studying and resolving health-related problems pertaining to uranium tailings.

Recent studies by the National Center for Radiological Health indicate that radon gas emanating from the piles requires further investigation. So that appropriate advice and assistance can be given the States with regard to any potential health hazard which may be associated with radon, the Public Health Service and Atomic Energy Commission are jointly investigating this problem. The scope and description of the joint PHS-AEC study is described in the project agreement entitled "Evaluation of Radon from Uranium Mill Tailings" signed by the Deputy Director of the Bureau of Disease Prevention and Environmental Control for the Public Health Service and the Director of the Division of Operational Safety for the Atomic Energy Commission, in mid-July, 1967. Copies of this document have been made available previously to the States concerned and we have additional copies with us today for distribution. The field activities of the Public Health Service in this joint study are under the direction of Dr. Dave Shearer, Chief, Technical Services, Southwestern

Radiological Health Laboratory, National Center for Radiological Health. Dr. Shearer, who previously introduced himself, is here at the conference.

In brief, air samples are currently being taken at the tailings pile at Grand Junction, Colorado, and also they will be taken at piles at Durango, Colorado, and Monticello, Utah, in an effort to evaluate the public health aspects of atmospheric concentrations of radon due to the tailings piles and to determine the effectiveness of containment in controlling the release of radon from the piles. The primary objective of this activity is to provide technical advice and assistance to the State regulatory agencies and to industry. All aspects of this program will be coordinated with the State health authorities of Colorado and Utah. Results will be made available to all interested State and Federal agencies. The participation of the Federal Water Pollution Control Administration will be sought should any water pollution aspects develop.

In summary, we feel there should be no undue delay in resolving problems relating to tailings piles to insure appropriate protection of the public now and in the future.

That is the end of my statement, Mr. Chairman.

CHAIRMAN STEIN: Are there any comments or questions?

MR. WRIGHT: Yes, I have one.

CHAIRMAN STEIN: Mr. Wright.

MR. WRIGHT: Mr. Nasi, can you make any statement as to what you have found as to the public health aspects of the radon gas? Is it a danger or not?

MR. NASI: I am pleased to have a question from Mr. Wright of New Mexico. None of the previous speakers received questions except from the Chairman.

I would like to call, with your permission, Mr. Chairman, on Dr. Shearer perhaps to answer that question for us, because he is the technical director of this particular program. And as you may also know, Dr. Shearer was associated with Dr.Tsivoglou in the earlier studies that have been previously discussed.

DR. SHEARER: At the present time we have just embarked upon this particular project. We have been gathering some results at Grand Junction. The results so far have been primarily to determine the analytical accuracy between our Public Health Service lab and the AEC lab in Idaho Falls. We only have preliminary data and are not prepared to reach any conclusions on the present data.

CHAIRMAN STEIN: Go right ahead.

MR. WRIGHT: Could I ask?

CHAIRMAN STEIN: Just continue.

MR. WRIGHT: My intent here is strictly for educational purposes. The radon gas effect on people, is it the gas itself as a gas problem to people or is it the radiological aspects of the gas that affect them?

DR. SHEARER: The gas per se is not the problem. It is the alpha decay products of the radon gas which are deposited in the tissues of the body that would be the problem, not the radon gas per se.

MR. WRIGHT: Thank you very much.

CHAIRMAN STEIN: Are there any further comments or questions?

You know, Kaarlo, this business of waste disposal is getting real complicated. We all have to call those experts. Up in Alaska--who is that fellow up there who used to remove that stuff?--you didn't have to call on a technical expert. He knew what he was doing.

MR. NASI: Yes, that is Mike up in Nome, "We take care of your needs."

CHAIRMAN STEIN: Right, that was his slogan.

You mentioned several of the mills, Mr. Nasi. Did you in the Public Health Service do any work on the Tuba City pile?

MR. NASI: Here again, if I might, I will defer to Dr. Shearer, who is intimately familiar. I might explain that Tuba City is not in Region VIII, so I would be out of my region.

Dr. Shearer can answer that.

DR. SHEARER: As a result of a request from the Navajo Tribal Council to the Division of Indian Health, Public Health Service, our center, in cooperation with AEC, conducted an environmental study of the Tuba City mill pile this past May. We have prepared the results into a draft report which is being circulated internally for technical review at the moment, and we have not released the data to the Indians in the formal manner and we are not prepared to comment specifically on the data as such. We did reach a conclusion in the report, which I am sure will stand, to the effect that the tailings pile should be stabilized in some satisfactory manner.

CHAIRMAN STEIN: Thank you.

Are there any further comments or questions?

If not, thank you very much, Mr. Nasi.

Mr. Schreeder.

MR. SCHREEDER: Thank you, Kaarlo.

I believe we have a statement from the Atomic Energy Commission. Donald Walker, Director of the Division of Compliance, Region IV, in Denver, will present the statement.

DR. WALKER: Mr. Chairman, Conferees, ladies and gentlemen.

We appreciate the opportunity of participating in the Sixth Session of the Conference on Interstate Pollution of the Colorado River and its tributaries. Since the last session of this conference was held over three years ago, we think it would be helpful to very briefly review the type of information presented by the AEC at the previous sessions. The actual statements presented were included in the transcripts of the proceedings.

During each of the previous five sessions of the conference we described, for the benefit of the Conferees, those aspects of the AEC regulatory program related to uranium milling activities which were germane to the matters being considered by the conference. At the First Session in January 1960, we described in some detail the AEC regulatory control program as related to uranium milling activities, including the licensing, inspection, and enforcement aspects. We also described research programs being conducted, such as the development of analytical techniques for assaying environmental radioactivity samples and the joint AEC-PHS evaluation of radioactive concentrations in effluents from representative uranium mills.

At the Second Session in May 1961, we described the nature and basis of the interim AEC effluent authorizations pertaining to the discharge into unrestricted areas of liquid effluents containing concentrations of radioactivity. Such authorizations, issued pursuant to Title 10, Code of Federal Regulations, Part 20, permit the licensee to utilize known stream or river dilution factors under certain specified conditions for the purpose of determining compliance with Part 20. Part 20 requires that concentrations of radioactivity in the mill effluent must not exceed drinking water levels when it leaves the licensee's control and enters the unrestricted area, except as may be specifically approved by AEC. Such approval may be granted where dilution factors are sufficient to provide assurance that at points of use of the water, concentrations of radioactivity are within the limits for unrestricted areas. Also, the mill operator must make a reasonable effort to minimize the radioactivity concentrations released.

Presently, three mills in the Basin hold such authorizations. The authorization at one mill is limited only to lead-210 for higher than Part 20 limits for continual release. The authorization at the second mill is only for radium-226, and this mill has been meeting the Part 20 limit at the point of release for the past two years. The third authorization is limited to thorium-230, and this mill is currently finalizing new waste treatment plans designed to minimize chemical pollution, but which should also reduce concentrations of radioactivity being released to well within Part 20 limits.

At the Third and Fourth Sessions of the conference in May 1962 and 1963, respectively, we described the joint effort being made by AEC and PHS--that is the former Division of Water Supply and Pollution Control--in developing embankment criteria for the construction and maintenance of earth dam retention systems at operating mills. The criteria were circulated to members of the conference and to the uranium mills for information and comment. A copy of these criteria is being furnished for the record of this proceeding.

The criteria deal with design features of earth dam retention systems, such as the dam height, the top width, the side slopes, freeboard, seepage control, protection of embankment surfaces and foundation design. The overall purpose of these criteria is to provide reasonable assurance that the earth dam retention systems are constructed and maintained in accordance with sound engineering practices so that the risk of dam failures due to anticipated conditions is held to a minimum. The criteria have been used by AEC in connection with the evaluation of applications for licenses, including license renewals and amendments, where earth dam retention systems are employed for retaining liquids which may contain concentrations of radioactivity exceeding the Part 20 limits for continuous release to unrestricted areas. All such existing embankment retention systems approved by the AEC have been evaluated against the criteria and the design features incorporated as license conditions.

Considerable improvement has been made in the stabilization aspects of such retention systems during the past several years. This has been evidenced by the reduction in the number of reported dike failures in earth dam retention systems which have been evaluated against these criteria. Since 1962, there have been only three reported occurrences of accidental release of uranium mill wastes from embankment retention systems. One of these was due to an operating error which resulted in an overflow of the retention system, but no dike failure. The second was due to failure of a dike in a retention system which had not been approved by the AEC. The other unplanned release of mill liquid wastes, not involving a retention dam however, occurred when thick ice on a tailings pond ruptured a pipe which permitted the loss of liquid. In this case, the concentrations released to the river did not exceed license requirements. Concentrations of radioactivity in the streams were within standards in each of the three cases.

We also described at the Third and Fourth Sessions a reporting requirement placed on all AEC-licensed uranium mills to assure immediate reporting of any failure of any earth dam retention system which resulted in release of concentrations of radioactivity to unrestricted areas. Upon receipt of such notification, the AEC notifies appropriate state officials and the FWPCA.

At the Fifth Session in May 1964, we discussed the evaluation of lead-210 concentrations in mill wastes and the steps the AEC was taking in dealing with the question of the ultimate disposition of uranium mill tailings.

In August 1963, in conjunction with its overall review of tailings at closed mills, the AEC requested the Division of Water Supply and Pollution Control of the PHS to review their data obtained by the Colorado Water Quality Control Project and provide us with an assessment of potential radioactivity pollution of rivers and streams resulting from tailings at closed mills. In March 1966, the FWPCA published its report entitled, "Disposition and Control of Uranium Mill Tailings Piles in the Colorado River Basin," which has already been discussed here in some detail. This report concluded, and I quote, that:

"Data obtained from the Radioactivity Monitoring Network operated by the Project demonstrates that the water pollution control measures practiced by the industry at operating mills have been very effective and there is currently no significant immediate hazard associated with uranium milling activities anywhere in the Colorado River Basin."

In May 1966, this report was subsequently discussed at hearings before the Subcommittee on Air and Water Pollution, United States Senate Committee on Public Works, as has already been mentioned. AEC views on this subject were presented to the subcommittee and the record of these hearings has been published also.

In December 1966, the AEC, PHS, and FWPCA each signed an agreement entitled, "Joint Federal Agency Position Regarding Control of Uranium Mill Tailings," which Dr. Mayo read in his statement. As indicated in this agreement, a copy of which we have also attached to the record, we believe tailings at closed mills should be structurally stabilized to minimize erosion. Planning, management, stabilization, and containment of tailings piles are viewed as being the responsibility of the individual mill owners. Compliance by mill owners with approved plans for stabilization and containment should be recognized as constituting fulfillment of mill owner responsibility with regard to such tailings piles. Obtaining plans of tailings pile stabilization and containment, and subsequent enforcement, should rest initially with the States concerned.

In summary, we believe the available evidence indicates that reasonable and sufficient efforts have been and are being taken to minimize water pollution from a radiological safety standpoint. Available data show that the concentrations of radioactivity in the Colorado River Basin are well within the radiation safety standards. Recognition should be given to the State of Colorado for developing requirements for stabilizing radioactive mill tailings and to the uranium milling industry for its cooperative effort with the State and Federal agencies. The AEC plans to continue its cooperative effort with Federal, State, and local authorities and with the milling industry to achieve an acceptable and reasonable solution for dealing with the uranium mill tailings. This effort includes making the benefits of our Monticello stabilization experience available to all interested parties.

CHAIRMAN STEIN: Thank you, Dr. Walker

Without objection, we will include your criteria pertinent to evaluation of embankment retention systems as an appendix, and I think we will include, too, the agreement here as an appendix, because this is dated. (See Appendix B and C.)

Thank you for a very excellent and comprehensive statement. Are there any other comments?

Mr. Schreeder.

MR. SCHREEDER: Dr. Walker, would you care to comment as to what extent, if any, the AEC could participate in the costs of stabilizing these piles?

DR. WALKER: I have present here a member of the Grand Junction staff, Mr. Frank McGinley, and Mr. Harvey Soule from the Division of Operational Safety. I might state that Frank's group at Grand Junction is the branch of the AEC who procured source material from various suppliers around the country.

Frank, I will comment on this if you prefer, or if you wish, you may comment directly on this.

MR. MC GINLEY: Go right ahead.

DR. WALKER: All right.

At the present time the AEC contracts with the mill operators have no provisions for any costs included in controlling or eventual stabilization, I should say, eventual stabilization of uranium mill tailings. At the present time, under the stretch-out agreement with the mill operators, the AEC and the milling industry are evaluating costs of milling on which the stretch-out contracts for 1969-1970, in other words the price that the AEC will pay for the uranium, will be based upon the costs which are under consideration at the present time.

Other than those costs, which we believe are a direct part of milling, in other words the creation of the dam retention systems or whatever other measures the mill may take to control tailings, both the solution and the solids at the present time, these costs, of course, I think, will be included in the cost that will be paid for uranium in future contracts.

I might add that up to the present time no mill has requested any information from the AEC as to what costs might be borne by the AEC should any future contracts be generated.

CHAIRMAN STEIN: Thank you, Dr. Walker.

Any further questions or comments?

MR. THATCHER: Mr. Chairman.

CHAIRMAN STEIN: Yes, Mr. Thatcher.

MR. THATCHER: I think this is an important point, particularly in relation to the long-term controls that we obviously are going to have to look forward to. I have covered this briefly in my statement, so with that I would like to defer and get into this question later when I make my statement.

CHAIRMAN STEIN: Well, again let me, as I see this, review at least the Federal agreement. As I see it, we are agreed that both inactive piles have to be structurally stabilized and active piles have to be managed to minimize erosion during use.

Now, the next sentence, and here is the key one, it says, "Planning, management, stabilization and containment of tailings piles are viewed as being the responsibility of the individual mill owners." And if this is the responsibility of the mill owners, the question of the operating financial responsibility, as I read this statement, might be included.

Now, the AEC may have a program, as we have a program, sometimes to assist municipalities in waste treatment works, but I am not sure, and this is the question I would like to bring up, if we are assessing responsibility for doing a particular job, the question is where the responsibility for that control lies, and I think as this develops you might consider that statement in what we have put forth.

I think Dr. Walker's statement is fully consistent with the joint Federal agreement, and if there is any question on that, we can wait on this and you can expand it with Dr. Walker.

MR. THATCHER: Well, I think my question will relate to that very sentence you have read.

CHAIRMAN STEIN: Right. All right. Well, thank you.

You will be here for the presentation of Mr. Thatcher, won't you?

DR. WALKER: Yes, sir.

MR. WHITE: I have the same concern, Mr. Stein, that there is an excellent job presently, there is an interim plan, but aside from Monticello, for a long-life hazard of this kind I have real concern.

CHAIRMAN STEIN: Dr. Walker?

DR. WALKER: Thank you.

CHAIRMAN STEIN: Thank you.

Are there any other Federal statements?

MR. SCHREEDER: Apparently there are no other statements by Federal agencies or entities.

If that is so, Mr. Chairman, this concludes the presentation by the Federal representatives.

CHAIRMAN STEIN: We will now call on the States, first Colorado.

Mr. Lewis.

MR. LEWIS: Mr. Chairman, I think one of the worst offenses that a sailor can have is if he doesn't show up in time to catch his ship, and this is just what happened to a sailor in San Francisco. He missed his ship and as he stood on the wharf and watched this wonderful piece of equipment go under the Golden Gate Bridge, he turned to the girl friend that was standing by him and squeezed her a little bit and said, "Now, honey, we are both in trouble." (Laughter.)

I think, Mr. Chairman, with the pressures that you have from the Congress and the pressures you put on us that we have had meetings, meetings, more meetings, conferences, until they are coming out of my ears. The Commission in Colorado had planned on taking July off for their vacations, since we did have a deadline to meet as of June 30, and I had planned my vacation in July. Of course I have missed that for this conference. And I will guarantee you, if you call another one for next month, I am going to refuse to pay my Federal income tax. (Laughter.)

CHAIRMAN STEIN: According to my daughter, who is out here, you are at a perpetual vacation place. (Laughter.) When she came into Denver and I saw her briefly, I said, "Where do you want to go?" She said, "Coors Brewery." (Laughter.)

MR. LEWIS: Thank you for the plug.

I think Colorado will reserve this right that you mentioned a little while ago that it could call on its experts. We do have two brief statements to make by two different representatives from the State of Colorado, and if it is all right with the Conferees and the Chairman, I would like to call on Mr. Fred Matter, the District Engineer, and he is also the Assistant Director of the Water Pollution Control Division of the State Health Board, for the first statement.

Fred.

MR. MATTER: Mr. Chairman, Conferees, ladies and gentlemen.

On January 26, 1967, Colorado's Board of Health Regulations, "Requiring Stabilization of Uranium and Thorium Mill Tailings Piles," became effective. Since that time, the industries involved have submitted their plans for stabilizing such wastes, together with an abatement schedule. All of these plans and abatement timetables have been reviewed by the Water Pollution Control Division and the Radiological Health Section of the Colorado State Department of Public Health, and have received the approval of the Department, both as to the plan and as to the time schedule proposed.

Last January, Colorado, together with the other six States of the Colorado River Basin, agreed to a set of guidelines that would be incorporated into the Water Quality Standards of all seven States of the Basin. These guidelines were incorporated in the Colorado Water Quality Standards for all surface waters in the State and were adopted by the State Water Pollution Control Commission on January 25, 1967. In these standards and those contained in an agreement reached by the seven States in the Colorado River Basin, the amount of allowable radioactivity in the stream is spelled out specifically. Both of these documents read, essentially, as follows:

These streams shall be, "free from concentrations of radioactive materials attributable to municipal, domestic or industrial wastes, or other controllable sources, which are physically and economically feasible to remove from said sources. In no case shall such materials in the stream exceed the limits established in the latest edition of the Public Health Service Drinking Water Standards, or one-tenth of the 168-hour week values for other radioactive substances specified in the latest edition of the National Bureau of Standards Handbook No. 69."

As a result of these two regulations, Colorado now has, we feel, effective regulations for both active and inactive uranium and thorium mills. We feel that we should now be given time in which to carry out these regulations.

This is the end of the statement, Mr. Chairman.

CHAIRMAN STEIN: Thank you.

Are there any comments or questions?

MR. WILLIAMSON: Murray.

CHAIRMAN STEIN: Yes.

MR. WILLIAMSON: I have a question maybe Colorado can answer or maybe someone else, but one idea that has popped up in my mind on this is we are trying to establish perpetual care here for these tailings piles. It looks to me like the State is going to own a large number of tailings piles in the very near future. I mean you don't pay your taxes on it and the State immediately gets it. Now, how are we forestalling this?

CHAIRMAN STEIN: Well, Art, Mr. Williamson, I think your point is well taken. As you know, we have a very analogous situation in the East - Pennsylvania, Kentucky, West Virginia, and Ohio - with abandoned mines, and this is one of our biggest headaches. So far we are making heroic efforts trying to solve that problem, but this is precisely what has happened, that when they moved away and we finally were aware of the problem, the States were left with the headache and it is, as you know, and has been a perpetual headache to us back there.

I think this is the question we put forward and you put forward. We have the golden opportunity now, before it is too late, to assess responsibility for the handling of the piles. Now, if the State is going to get these anyway, I think you may consider it might be better to get them under a situation of perpetual care than a perpetual headache, and I don't know that we can deal otherwise with the facts of the situation.

But I would suggest, sir, that the right of reversion of any land to a State or land use is properly one of the relationship of the State and the industry within that State and not for the Federal government. This is a vital problem, I think, but except when you are dealing with a direct Federal function at a national park or a national forest or a dam or anything of that kind, it seems to me that the Federal government has to stay out of land use relationships. We may deal with air pollution or water pollution or safety consequences once you have decided on the land use operation, but the question of land use is something that I think the States should think of very, very hard before they get the Federal government in it. This is a question that comes up repeatedly. As a matter of fact, it is a general point of view. Except in a special case like this, it has been my experience that determinations of land use are often best left on a local basis and shouldn't even be handled by the State.

But what you are raising, Mr. Williamson, is a very key question, and I think if you have any thoughts or if you think it is appropriate for the Federal Government or any of its agencies to consider any of the aspects, get that in anyway and we would be glad to consider it. But I think this is the key question. I don't know that the Federal Government could prevent any land from coming back to a State because of abandonment or nonpayment of taxes. What we can do is hope that you are going to get it back, if you have to get it back, in a shape where you will not have a difficult time through the years in preventing a deterioration of the other natural resources.

MR. WILLIAMSON: I certainly agree that this is a State function, and I was just wondering what considerations the State of Colorado, which has already adopted standards, has given to this aspect of it. What is the answer, if you have one, Howard?

MR. LEWIS: We do have another--

MR. BONDERSON: Mr. Chairman, might I comment at this moment briefly?

CHAIRMAN STEIN: Yes.

MR. BONDERSON: There seem to be some discussions here tending to, let us say, put the responsibility on the State and sort of taking the Federal Government out of the responsible position. I am not very familiar with the AEC arrangements, but apparently the Federal Government is the only purchaser of uranium. Is that right?

CHAIRMAN STEIN: I couldn't answer that. Dr. Walker?

DR. WALKER: At the present time there are a number of private contracts and there are a number of mills which are in operation and licensed either by the AEC or by an agreement status where the AEC does not purchase the final product.

MR. BONDERSON: Well, the principle applied to both of those, so it is not only to the Federal government but to the private.

It appears that the mine or milling operators are responsible for not only the interim, but the long-range effects of their tailings, and it would appear that in evaluating their costs that it is most appropriate, legitimate and proper that the cost of interim and long-term protection be included in their negotiating their prices in their contracts and that the industry, I think, should be encouraged to do this not only with the private operators, but those who are dealing with the Federal government, that the income that they must derive from their operation must be sufficient to also take care of their costs. So indirectly, the Federal government, where they are dealing with them, should be paying the costs. You can't expect this to come out of the profits or there wouldn't be any profits.

So I would hope that industry and the AEC would encourage the industry to very thoroughly evaluate their costs and take into account interim and long-term protection of the tailings piles.

CHAIRMAN STEIN: Any comment on that?

If not, Mr. Lewis, do you want to try to respond to Mr. Williamson?

MR. LEWIS: I was going to say, Art, that we do have a statement in part of our regulations that says that all State and Federal agencies will come under the same regulation as our industries do in the State of Colorado. The Federal agencies have to comply with our regulations as well as anyone else does, and if it is where the State does take it over and would have to take it over, they would have to, the State, foot the bill for this.

I agree over here that there should be at least enough profit or some money in here some place where, if it does go back to the State, there would be Federal monies enough to stabilize these tailings piles, but we are not sure that this will happen.

CHAIRMAN STEIN: Howard, let me just say this for the record, as to your statement that the Federal government will have to comply with the State regulations. Our participation in this doesn't indicate any agreement on that by the Federal people. (Laughter.)

This is a question which you know is a difficult one and can't be solved. I am saying that for the record and outside the purview of this conference.

MR. LEWIS: I think you have seen the stage being set, but what Mr. Matter has said here on the regulations that we have adopted, we have gone a step further, we have, with the aid of industry, had hearings on the mine tailings, on the piles, and we have come up with a sea of dates, abatement schedules, and I think maybe this will bring out a lot of questions from our Conferees.

But at this time I would like to call on Dr. Jacoe, P. W. Jacoe, who is the Chief of the Radiological Health Section of the State Health Department, to present the abatement schedule for the industries in the State of Colorado.

DR. JACOE: Mr. Chairman and Conferees, my statement will consist merely in briefly summarizing the stabilization schedules according to compliance with the regulations that were adopted.

CHAIRMAN STEIN: Will you identify yourself for the record, please.

DR. JACOE: Dr. P. W. Jacoe, Chief of the Radiological Health Section of the Air, Occupational and Radiological Hygiene Division of the Colorado Division of Public Health.

A matter of clarification of one of the

previous statements where the two sets of regulations have been adopted by the Colorado Department of Health. The one last September that was mentioned, I believe, by Mr. Mayo was not a regulation; it was orders by the Board of Health for industry to submit by a certain date plans, if any, for stabilization. As a result of what industry submitted, then the official regulations were promulgated and adopted.

The following is a brief summary of the proposals offered by industry to stabilize inactive mill tailings piles for compliance with the Board of Health regulations. These are as accepted by the Board of Health.

Uravan. It is a small inactive pile covering about five acres. The tailings are to be retrieved from the river bank, side slopes reduced, the southern and eastern edges are to be riprapped, the top of the pile leveled and covered with six to twelve inches of gravel. The schedule for completion is for the latter half of 1967.

Slick Rock. The pile here has lower radioactivity than any other inactive site. The tailings adjacent to the river are to be retrieved and the entire river site to be riprapped with large rocks. Drainage ditches will be installed on the uphill side to divert surface runoff. Steep slopes are to be eliminated and covered with an earth-rock mixture of adequate depth to prevent wind erosion. This project is scheduled to be completed in the latter part of 1967 or early part of 1968.

Maybell Plant. This pile is also not as radioactive as most of the others. Ditches will be dug around the north and west side to drain surface runoff and riprapping added on the south and east outfacing slopes. The entire pile to be planted or stabilized by some other means. The project shall be completed by January 1, 1969.

Rifle Plant. This pile has now been properly stabilized. Now, I am speaking of old Rifle, which is a non-operating mill site. Drainage has been provided, it has been leveled, covered and planted,and a good growth of grass has been established.

Durango. Re-distribution of the Durango piles, and there are two piles there by the way, will involve combining the small pile with the large pile and establishing a slope substantially less than the critical angle of repose. The toe of the pile will be 25 to 50 feet above flood stage of the Animas River. After leveling and contouring is completed, a ditch four feet wide by four feet deep will be constructed on top of the consolidated pile to discharge runoff water. Covering and planting will be done and completion date has been set as June 30, 1969.

Naturita. This pile has already been leveled and contoured and will have a rock barrier between the pile and the river. This pile will be covered and planted and completed by December 31, 1968. If it is determined feasible to rework the Durango and Naturita tailings piles for uranium and vanadium, an application will be made to the Board of Health and a new time schedule adopted regarding any changes. This has not been discounted or entirely solved, but industry will by September decide definitely as to whether they want to rework these tailings piles or not for the value still contained therein.

Gunnison. The tailings pile at Gunnison was acquired by Colorado Ventures in Grand Junction, Colorado. An agreement has been signed between Colorado Ventures and the County of Gunnison concerning the use of a portion of the tailings material for construction of the expanded runway at the Gunnison airport. Work is expected to start on this project this fall. Upon removal of the tailings required for runway construction, Gunnison County has agreed to use the material in the dikes to cover the remaining portion. If there is insufficient material in the dikes, Colorado Ventures has agreed to complete the project. Completion time has been designated as December 1, 1967. Due to a slight delay in getting required approval for expansion of the airport, it may be necessary to revise this schedule. Also should an early fall and winter occur, this project may not be completed until early spring of 1968. In this case a request for an extension must be furnished the Board of Health.

I would like to make an addition, although it is not present in the written statement that I have prepared, in anticipation of questions, an addition for the record, that we realize that promulgation of regulations and compliance by industry is not a solution to the problem, either immediate or permanent. Therefore, we have submitted a long-range plan for continued inspection of all stabilized uranium mill tailings piles, and this plan involves inspection to determine the efficiency of stabilization, any weak spots that may occur, and also monitoring for effects in the biosphere, monitoring for radon will be continued, and monitoring for radioactivity in air and water in these areas will be continued. We plan to set up one or two surveillance stations in the uranium milling country, that is in Grand Junction and/or Durango.

That concludes my statement.

CHAIRMAN STEIN: Thank you, Dr. Jacoe.

Any comments or questions?

Yes, Mr. White.

MR. WHITE Dr. Jacoe, as you were describing some of these corrective processes or stabilizations, they sounded to me to be a little bit on the permanent side. Now, I was quite concerned when I saw some of those pictures up there. They looked to me like there was a maintenance during an interim in operating cycle, but as soon as this was gone you had tailings all over. But as you have described this,

this is reasonably permanent, isn't it?

DR. JACOE: Yes, Mr. White, reasonably permanent, and based so far on the experience at Monticello. The proposals as submitted are all based on that.

Now, the regulations, which I think most of you have copies of, do not limit the mill owners and mill operators to that method of stabilization. Perhaps two or three years from now someone may come up with something that is more effective. Therefore, they will not be limited to using this method.

However, it is permanent so far as we know. I think Monticello has been stabilized for about four or five years now and it looks very good. These are basically the plans that most of the operators are going to use.

MR. WHITE: Would it be reasonable to have a regulation? Of course, California probably has more land ruined by the gold miners in their placering operations, but I think you have a law there, Paul, that says you have to replace the excavated soil in its original state and stabilize it. Is this what you are trying to do? Is this a reasonable regulation, that from the time of the licensing of the operation this could be included as a clause?

DR. JACOE: No, there will be no removal at all. The piles are to be leveled to the extent that they will be stabilized to prevent blowing and covered with dirt and rock or any such mixture of that or they could be sprayed with an asphalt material.

MR. WHITE: Is this in your regulations?

DR. JACOE: This is in the regulations, yes.

CHAIRMAN STEIN: Any further comment or question?

Mr. Schreeder.

MR. SCHREEDER: Dr. Jacoe, in talking about this Durango Vanadium Corporation mill, I am interested in what you are going to do with that diversion ditch on top of that pile. What are you requiring the mill to do to make sure that you don't create an erosion problem in that ditch with water runoff?

DR. JACOE: Well, if I understand your question correctly, you know that the Durango pile is situated in a rather narrow canyon up against a very steep slope, and of course there is a lot of runoff water during periods of rainfall that would come down this steep slope, and if the drainage ditch around the upper part of the pile were not installed the water would then wash over the stabilized portion of the tailings and perhaps it would wash out the dirt of the plant growth. The ditch would collect the water from the steep slope above the tailings pile and divert it away from the stabilized portion of the pile.

Does this answer your question? Is that what you meant?

MR. SCHREEDER: This ditch is not going to be on the pile itself?

DR. JACOE: No. No.

MR. SCHREEDER: All right. That satisfies me.

CHAIRMAN STEIN: Are there any other questions?

Dr. Jacoe, who is going to do this monitoring? Is this going to be a State project that you are proposing?

DR. JACOE: This is a State project to be done by the Radiological Health Section with cooperation with the Water Pollution Control Section in the Health Department.

CHAIRMAN STEIN: In the mills you listed did you list all the active and inactive mills in Colorado in your list?

DR. JACOE: No. The regulations apply only to the inactive mill sites.

CHAIRMAN STEIN: Right. This is what I was getting at. What are you going to do about the active mills? Do you have a program for managing those piles to minimize erosion from those during operations?

DR. JACOE: We are encouraging sprinkling, for example, to minimize blowing dust, and this has been accomplished in some of the areas, inspectional programs, of course, carried out by the AEC. We do have statements from two of the operating mills as to what they are going to do when these mills are no longer operating on stabilization.

CHAIRMAN STEIN: We recognize, and I think you have, at least it seems to me, an excellent program for inactive mills. But the question here is are you contemplating having that kind of a vigorous program, considering the nature of the problem, of course, for active mills as well as inactive mills, something more than perhaps encouragement?

DR. JACOE: I would say not at this time. We have nothing to indicate that there is a problem with active mills. Nothing has been presented to really show that we should go into active mill sites.

In other words, the statements earlier this morning, and in the brochures that have been prepared, have all stated that the problem of stream pollution regarding active mill sites has been eliminated, if we can lick the air pollution problem, which we are trying to do by sprinkling and any other means that they want to do. They are planting one of them, for example, and getting a good growth of grass on certain areas. This is an active mill site.

CHAIRMAN STEIN: Well, but they are doing something. The point is that I really don't understand the distinction. I think I have seen a representative number of uranium mill piles. They look to me like big piles of sand, as described by Mr. Mayo, 20, 30, 40 feet high, often stretching for a quarter of a mile, subject to wind or water erosion.

Now, it doesn't seem to me, if someone is working a quarter of a mile away on a pile, that the end not being worked is any different or that we have very much of a different problem than an abandoned pile or an inactive pile, and I don't understand the difference in philosophy in just getting at inactive piles and not worrying about active piles.

DR. JACOE: Well, let me go on just a little. I will acquaint you with the situation in Grand Junction.

The entire pile is covered by Rainburst, which is a sprinkling system. These are in operation 24 hours a day. The entire pile in one day or any portion of the entire pile in one day gets at least eight hours of sprinkling to reduce the dust and to eliminate the dust.

Now, if we want to discuss the problem from all the aspects or from the water pollution aspects only, of course that is a different thing, but we have no indication, as long as the company is operating the mill, that the containment of the dikes will fail to the extent that it does become a stream pollution problem. I think that all the reports have shown that the radioactivity levels in the streams have not been in excess of any standard since 1963.

CHAIRMAN STEIN: Let me try to do this. I think after much thought and negotiation and hard work, the Federal government agreed that active piles, active tailings piles, should be managed to minimize wind and water erosion.

Would you say that all the active piles in Colorado were being so managed as to minimize such erosion during use?

DR. JACOE: I conceive that we have no information to make a statement to the contrary. I will add this, that we are studying the situation very thoroughly and will continue to do so, but we do not have any information at this time to show that the containment on active mill sites, we will say, needs any further procedures.

CHAIRMAN STEIN: Maybe Mr. Lewis can answer part of the question.

But you know, it seems to me that you have such a thorough report - and I think it is very commendable, one of the best pollution reports I have ever heard, and as you know, I have been at a lot of these things - but the thing about the active piles is you say you have no information that anything is bad. The question here, if we are talking in terms of managing the active piles, it seems to me like with any discharge we should be able to say that the situation is such, is so managed, that they are not going to have any wind and water erosion. Our experience in the past has been that unless we give each one of these situations full attention--this isn't true just with uranium wastes, it is true in any water pollution control--the likelihood is it doesn't take care of itself.

I think the Federal statement was that active piles should be managed to minimize water and wind erosion during use. It seems to me that that calls for some kind of an active program, and the contrast between the two programs in the State is kind of striking.

DR. JACOE: Well, do you mean that it calls for an active program on the State level or on the Federal level? Doesn't the AEC have jurisdiction over this active mill sites?

CHAIRMAN STEIN: I am not speaking about AEC jurisdiction. But we have just heard Mr. Lewis speak for the State of Colorado and talk about all the Federal agencies complying with State law, but this isn't a question of a Federal agency along with private enterprise complying to state jurisdiction. So let's not try to get at a jurisdictional question - whether wind and water erosion come under State or Federal jurisdiction. I think the first thing we have to determine is whether we do have a problem here that needs some kind of attention from someone, State or Federal, to handle, and we always prefer the State to do it.

Now, I think you have come up with a brilliant exposition and a detailed one on the inactive piles. The point that I am getting at is, I think before we can walk away and say we don't have a problem on the active piles, it seems to me we need that kind of analysis and effort put forward to determine whether this is a problem or not. Evidently the assumption was made in the Federal agency statement that there will be an active management program on the active piles.

Mr. Lewis, do you have a comment?

MR. LEWIS: Yes. I might say that the regulations that were written are on inactive piles where the authority lies at that time. At the present time, covering some of our active piles and the regulations that the AEC has written on stabilizing and building these dams or dikes, we do have an engineer, he is working on it at the present time, in the Water Pollution Section that is re-evaluating what the AEC has said in their report on slopes, on top cover, this type of thing, on the active piles and on all piles from every mine in the State of Colorado.

Our problem isn't from the two or three radioactive mines we have. It is all the mines that we have in every canyon in Colorado that is taking out silver and gold and everything else that we are worried about, and with the price of silver going up we know this silver industry is going to boom.

So we are trying to come up with some type of a regulation or a recommendation on how each one of these mines will build their **pile of tailings** on the side of a mountain to keep it from going into the rivers. At the present time we have Mr. Campbell who is working on that. I think as of the September meeting he will have a report for us on not only the active mine tailings, but all mines in the State of Colorado.

CHAIRMAN STEIN: Right. Thank you, Mr. Lewis.

Now, one more question, this is largely for the record. Have you found responsible parties for all these inactive piles that you talked about in stabilization? In other words, there is an industry in each case that you feel is responsible for this corrective work? Is that so?

DR. JACOE: In all cases but one. The Gunnison mill is not strictly under the jurisdiction of an industry. You see, that is an abandoned site and the property was purchased by another company, and it amounts to a three-way deal, a three-way contract between the county commissioners of Gunnison County, the company that bought the mill site, and the people who are negotiating to construct a runway.

CHAIRMAN STEIN: I recognize the complications here, but do you feel that you are going to have parties that you are going to look to, specific parties, to do the work?

DR. JACOE: Oh, yes, definitely.

CHAIRMAN STEIN: Right. This was the question, again to refer back to Mr. Williamson, that you are not going to have it abandoned and put back on you. You do have parties that the State believes are responsible to do the work in all cases?

DR. JACOE: The work will be done initially now by the people who own it, which will be the companies. Now, if you are talking about the future, the responsibility for maintenance will be on the people who own that mill site, if it reverts back to the State or the county.

CHAIRMAN STEIN: I recognize that. Let's get to the initial question. You went down a list of mills outlining with particularity work to be done. Do you have parties that the State agency believes are responsible to do the work in each case?

DR. JACOE: I don't believe I get what your question is.

CHAIRMAN STEIN: For example, you named one of the mills. On that site, who do you expect to do the work? Have you served an order against someone?

DR. JACOE: It is up to the mill to do the work.

CHAIRMAN STEIN: I know.

DR. JACOE: They can contract it out or do it themselves.

CHAIRMAN STEIN: No. I am talking about the legal responsibility. What I am saying, you have named all the sites, is there someone legally responsible that you have in mind for each of these sites to see that the work is done?

DR. JACOE: If the regulations are not complied with, then it goes to the Attorney General's office.

CHAIRMAN STEIN: I understand that. Let's get this again.

I hate to single out any mill, but suppose you had a mill, and let's just give as an example the XYZ Mill at Brighton, where there is obviously no mill, you can proceed once you put this out, the XYZ Company has to do the job. The question that we have in various parts of the country with mill sites, and let's just suppose you went up Clear Creek or Cripple Creek and looked at those, you could pass all the regulations in the world, but who is going to do the work?

The question that I am asking you is, for every one of those recommendations you have made on each mill is there someone out there who you feel is responsible to do the work?

DR. JACOE: Someone within our department?

CHAIRMAN STEIN: No, outside the department. Certainly not in your department.

DR. JACOE: I certainly don't understand, because it is the responsibility of the mill owners to do the work.

CHAIRMAN STEIN: Is there a mill owner in each case?

DR. JACOE: There is a mill owner in each case.

CHAIRMAN STEIN: All right, thank you.

DR. JACOE: Except Gunnison, certainly there is.

CHAIRMAN STEIN: What do you have at Gunnison? Do you have anyone out there who you feel is responsible to do the work, or is that going to be a State job or an empty order?

DR. JACOE: Yes, the county commissioner.

CHAIRMAN STEIN: And you feel that they are responsible?

DR. JACOE: We have a signed agreement.

CHAIRMAN STEIN: Right.

Again I would like to commend you on the program. I note, check me if I am wrong here, that the last date of completion of any of these inactive piles for the stabilization you have outlined is going to be in 1969. The dates are between 1967, 1968, and one in 1969. Is that correct?

DR. JACOE: Yes, sir.

CHAIRMAN STEIN: I think that is a commendable program and one that I think if we can do that with all the mills we will be well on our way.

Thank you very much, Dr. Jacoe.

MR. LEWIS: Thank you.

This completes Colorado's report.

CHAIRMAN STEIN: May we call on Utah, Mr. Thatcher.

MR. THATCHER: I have a prepared statement, Mr. Chairman, that I will read to save time.

Radioactive wastes received prominent consideration when the Colorado conference was initially called in 1960, but it was recognized then, as now, that they constitute only one facet of a highly complicated waste management problem. Specific waste discharges containing radioactivity have been successfully treated until present river contamination of this type is at an acceptable level. The problem now under consideration is the long-term potential hazard posed by radium, thorium and related substances in tailings piles. Because of their extremely long half-life, and despite their low-level activity, they conceivably could become hazards as a result of wind or water erosion, leaching and possible uptake into the food chain, either by way of aquatic life or as a result of irrigation.

It seems quite obvious that considerably more knowledge will be necessary before a final solution to the problem is found, but this should not constitute an excuse for ignoring interim control measures which appear to have merit.

A difficult aspect of the problem is its permanent nature. This, coupled with the acknowledged need for more information, pinpoints the necessity of establishing some mechanism for long-term control beyond any limits normally considered in waste management. It appears to us that this is the key problem to be faced by this group.

Since this conference is oriented to problems of water pollution, a question could be raised as to the propriety or even practicability of the Federal Water Pollution Control Administration sponsoring the control measures necessary for public protection, inasmuch as part of our concern is tied to air pollution. Furthermore, radiological health, another important division of public responsibility in the overall matter of environmental impact, must be given full consideration, whether our concern is air, water or food.

It is not suggested that these questions demand an immediate change to different methods of approach, but they do show the need for careful attention to all aspects of the problem and for recognition of all agencies concerned. This is only to stress the obvious, that environmental pollution control is basically a problem of pollutant management, which is difficult to divide between different agencies concerned with only a single aspect of environmental pollution.

In Utah, plans have been made to adopt regulations on interim measures to control uranium and thorium tailings under authority of a new radiation protection law which became effective in May 1967. The procedure involves initial drafting of possible standards based on existing information, review and modification by our Radiological Health Advisory Committee, submission to public hearing, and finally, formal adoption by the State Board of Health.

In following this process, we have the privilege of reviewing regulations already produced by the State of Colorado, plus various comments relating to them. The usual principles of containment against water and wind erosion and minimization of leaching are expected to be followed, with recognition that additional knowledge is needed and that it should be put to practical application at a suitable future time after it is well established. We also intend to continue our past practice of prohibiting removal of tailings material except for specifically-approved uses. Time schedule for the process of adopting regulations is not firm, but it is expected to be complete within a year.

The present status of control efforts at the various tailings piles in Utah is as follows:

Hite, Vanadium Corporation of America, non-operating. This was a small pile and it is now innundated by the waters of Lake Powell. The Colorado River Basin Water Quality Control Project report of March 1966 states that "high grade" tailings were removed from this pile and that recent tests show it to be well covered with sediment. It is not considered to be a pollution threat.

Monument Valley, Vanadium Corporation of America, operating. There seems to be some confusion regarding location of this pile. In one recent mailing, the Federal Water Pollution Control Administration showed its location as Utah and in another as Arizona. In any event, it is reported to be quite isolated with respect to both human populations and streams, but no doubt should be considered for proper interim controls with others. We would appreciate having the Federal Water Pollution Control Administration settle the question of location. (Laughter.)

CHAIRMAN STEIN: Are you assuming jurisdiction?

MR. THATCHER: No. As a matter of fact, I am going to disclaim it in a minute.

CHAIRMAN STEIN: Oh. (Laughter.)

MR. THATCHER: I note that the agenda for today definitely locates the pile in Arizona, and Utah will have no reluctance in letting Arizona have this problem.

MR. GILBERT: Thanks a lot.

MR. THATCHER: Don't mention it.

Monticello, U. S. Atomic Energy Commission, non-operating. This pile was given interim containment treatment by the Atomic Energy Commission, apparently with full success. Radium-226 contamination of adjacent waters developed while the mill was in operation and apparently is subsiding. Joint Atomic Energy Commission and Public Health Service studies have been started to determine radon-radon daughter levels in areas near the pile, but results are not yet available, as has already been mentioned by Dr. Shearer.

Mexican Hat, Atlas Minerals, non-operating. Atlas Minerals reports that work done toward stabilization here "involved the leveling of the peripheral portion of the storage area to eliminate the peaks and valleys related to wind erosion. An earth fill dike from six to eight feet high was built outside the exterior toe of the pond structure to contain berm erosion that might result from direct precipitation. Diversion channels were provided to carry precipitation runoff from higher ground around the storage area."

The State has not made specific requests for interim measures, but intends to do so following adoption of regulations.

Moab, Atlas Minerals, operating. Atlas Minerals voluntarily conducted special studies to determine a feasible method of stabilizing the dikes of this active pile and report to us earlier this month that "the inner portion or nearly level actual pond area is relatively dust stable due to moisture from the input tailings flow. The exterior of the berm has been covered with shale to a depth of 15 to 18 inches. Coverage now exists over about 90 percent of the exposed area. An additional 5 percent is expected to be completed during the current month. On the next relocation of distribution piping, possibly in about one year, to increase berm elevation, access will be provided to permit 100 percent berm coverage with shale."

Green River, Union Carbide Corporation, non-operating. Union Carbide Corporation voluntarily submitted plans on May 1, 1967, covering containment of the pile at their closed Green River, Utah, facility. The plans conformed to recommendations of the Federal Water Pollution Control Administration as stated in their March 1966 report. Utah's reply, late in June, approved the plans with minor reservations, including reference to possible requirements of future Utah regulations, whereupon the Corporation suggested delaying actual start of construction until the regulations are finalized.

Vitro Tailings Pile. It seems desirable to mention another uranium-thorium tailings pile problem in Utah, even though it is located outside the Colorado River Basin. This is the pile at the Vitro **Minerals** and Chemical Company plant near Salt Lake City. The company ceased processing uranium ore several years ago, but is still in operation for production of vanadium. In terms of proximity to a large population center, the Vitro pile may be of greater importance than many others. We have recently asked that it be included in the Atomic Energy Commission-Public Health Service studies and hope this can be accomplished soon.

Joint Federal agency position. We have

studied the joint position statement regarding control of uranium mill tailings recently adopted by the General Manager of the U. S. Atomic Energy Commission, the Assistant Secretary of Health, Education and Welfare and the Assistant Secretary of Interior, and we consider it to be sound and adequate except for the reference to fulfillment of responsibility to control tailings piles upon compliance with approved plans. We have all acknowledged that more information is needed before a final answer to control can be developed. And yet we must proceed to develop and enforce regulations without waiting for this knowledge. It is quite likely, in this context, that further controls will be necessary at some future time, long after initial regulations have been met.

We do not suggest that industry should be expected to assume this burden. In fact, it seems evident that this was not the intent when uranium contracts were first established. Furthermore, it is not the type of burden which States can assume. We suggest, therefore, that further consideration be given this matter, with some additional deliberation on some earlier suggestions that the Atomic Energy Commission look to the possibility of assuming or underwriting long-term controls.

That concludes my statement, Mr. Chairman.

CHAIRMAN STEIN: Thank you, Mr. Thatcher.

Any comments or questions?

I think you have raised a very serious key question that has to be considered by the Conferees in executive session, and that is on the matter of responsibility. While I don't think the Federal agreement has come out with a position, I can understand the force of your views. But I think this is something that the Conferees should give some thought to and some private discussion, because this is a vital question in the whole operation.

MR. THATCHER: This is the approach I would like to see.

CHAIRMAN STEIN: Well, I think the Conferees will have to consider that.

I ask this for the record. You have covered all the mills, haven't you?

MR. THATCHER: And the one in Arizona.

CHAIRMAN STEIN: The one where the company suggested waiting for the regulations, what is the situation there? Are you going to let them wait or are you going to try to proceed?

MR. THATCHER: I think Utah feels that this is a logical request on the part of industry from the standpoint that they do not at this particular moment know the exact nature of our regulations, and since we are already in process of developing them we feel that it is a valid request that we will honor.

CHAIRMAN STEIN: Thank you.

MR. WRIGHT: Mr. Chairman, Dr. Shearer wants to ask a question.

CHAIRMAN STEIN: I think we are not taking any from the floor.

MR. WRIGHT: Oh, I see.

CHAIRMAN STEIN: Are there any further comments or questions?

If not, let's go on to Arizona.

MR. GILBERT: Mr. Chairman, Conferees, ladies and gentlemen.

There are two uranium mills in Arizona, the El Paso Natural Gas Company operation at Tuba City, and the Vanadium Corporation of America's Monument No. 2 upgrader east of Monument Valley. The former ceased active processing late last year and the latter is still in operation.

The Arizona State Health Department expressed an interest in the public health aspects of the Tuba City mill as long ago as November 1965, when I prepared a three-page report recommending that the tailings piles be stabilized. The Department was using its good offices only, as the United States Atomic Energy Commission still held the mill's license and the mill was located on the Navajo Indian Reservation. The United States Atomic Energy Commission, the Navajo Tribe and the Division of Indian Health, United States Public Health Service, then appeared to hold primary jurisdiction in the matter, and the State Health Department did not pursue the subject actively any further.

Arizona became an agreement State under Section 274 of the Atomic Energy Act of 1954 as amended on May 15, 1967. As part of the preparation for this take-over of part of the regulatory program from the United States Atomic Energy Commission, the question of jurisdiction over these two mills came up. It was, as I recall, late in April that the United States Atomic Energy Commission decided the licenses would be transferred to Arizona, on the basis that while the Navajo Reservation was a Federal jurisdiction it was not an exclusive Federal jurisdiction. Thus it has been only recently that the State has had to definitely say something about the tailings piles. By this time, also, I had personally transferred from the State Health Department to the newly-staffed Arizona Atomic Energy Commission, the State agency which does the actual licensing of persons using radioactive materials, and the agency which has legal responsibility for protecting the public against the hazards of ionizing radiation.

In May of 1967 a detailed survey by the National Center for Radiological Health was made of the tailings pile at Tuba City. As this should be an impartial, authoritative consideration of the health hazards at the mill, the Arizona Atomic Energy Commission will surely be guided by their findings in its administration of the El Paso company's license. Should it be recommended by the Public Health Service that the pile be stabilized against wind erosion, this is the measure we will presumably invite the company to undertake.

The Vanadium Corporation of America mill is still in operation. Because of its geographical isolation and the distance from the nearest watercourse, the tailings pile there represents, to us, a very minimal health hazard. I think that for our guidance and for the record, we will ask the Uranium Mill Tailings Project of the Southwestern Radiological Health Laboratory, National Center for Radiological Health, Public Health Service, to survey the pile and determine the extent of hazard there, if any, at an appropriate time in the future.

The above comments have been reviewed by Mr. Edmund Garthe, the designated Conferee to this conference, and he has indicated to me his concurrence in the essence of the material presented. He also asked me to convey to the other Conferees his greetings.

CHAIRMAN STEIN: Thank you very much. I wish you would give our greetings back to Ed, too. It seems as if this gets to be an inbred society. I used to work very closely with him about 15 years ago.

Are there any comments or questions?

As I understand it, we did hear from the Public Health Service representative today that they were going to recommend stabilization of that Tuba City pile.

MR. GILBERT: Yes, and we will work with the Division of Indian Health as a very overpowering responsibility in the area on the Indian reservations, we will work with them and ask the El Paso Natural Gas Company to stabilize the piles.

CHAIRMAN STEIN: Right.

MR. GILBERT: Perhaps I should have asked if there is anybody from the Vanadium Corporation of America here or the El Paso Natural Gas Company?

I talked to Mr. Hollis of the El Paso company yesterday and he said he wanted to be here, but he couldn't make it.

CHAIRMAN STEIN: As far as your other piles, then, you have no definitive conclusions on them?

MR. GILBERT: No.

CHAIRMAN STEIN: They are still pending

study and evaluation?

MR. GILBERT: Right.

CHAIRMAN STEIN: Is that correct?

MR. GILBERT: Yes, sir.

CHAIRMAN STEIN: Are there any other questions?

There is one thing about this business I think we should realize. I don't know that I have heard that the protective devices to prevent water or wind erosion are any different. In other words, if we protect one, as far as I have been able to understand this operation, we are protecting against both. So the main thing, if there is a problem, is to get the pile protected.

May we call upon New Mexico?

MR. WRIGHT: Thank you, Mr. Chairman.

Mr. Chairman, fellow Conferees and ladies and gentlemen. I don't want you to think that the hippies have taken over New Mexico, but our Santa Fe Fiesta is coming up in September and I think I should be on the side of the Spanish and not the Indians, since the Spanish did win.

During the last legislative session in New Mexico, both the Water Quality Act and the Air Pollution Control Act were passed. The Water Quality

Control Commission, working under the deadline of June 30, has taken action on water quality standards. The State has adopted water quality standards effective in the Colorado Basin which establish limits on radioactive contaminants. These standards were adopted by the Water Quality Control Commission on June 6, 1967.

The Air Pollution Control Board is the State Board of Health in New Mexico. The Board has not yet adopted any regulations regarding air pollution.

New Mexico also has a Radiation Technical Advisory Council, whose comments regarding control of uranium and thorium piles have been requested. The Technical Advisory Council is now studying the uranium pile problem and will report and recommend to both the Air Pollution Control Board and the Water Quality Control Commission. Positive action by the Board and the Commission will follow the Advisory Council's comments regarding regulation of the piles throughout the State, as well as within the Basin.

At this point I would like to report on the one pile which we have in the Basin, the Vanadium Corporation of America mill at Shiprock.

The Vanadium Corporation of America is in the process of covering their tailings pile with soil. The covering has been partially completed on the east slope, and work is in progress on the north slope. The cover consists of pit run gravel mixed with sand and soil which will support vegetation. The large stones being used exceed six inches in diameter in order to give the cover good stability.

The cover will be approximately 2 feet thick at the base of the slope and 18 inches at the top, depending upon the natural angle or repose of the cover material. The cover is being placed on the side slopes only at this time, as the surface of the pile is still active.

Not speaking for either the Water Quality Control Commission or the Air Pollution Control Board, but to present the basic thinking of the administrators in New Mexico, we see the control of uranium and thorium tailings piles as a necessity for the protection of the environment from nuisance contamination, but we do not see the piles as a public health hazard or public health threat. This was my reason for my questioning of the Public Health Service.

I would like to also comment that the State of New Mexico supports Mr. Bonderson's earlier statement regarding long-term responsibility for the piles and cost responsibility for the covering of the piles.

Thank you, Mr. Chairman.

CHAIRMAN STEIN: Thank you.

Are there any comments or questions?

When will the stabilization of that pile be completed, of that active pile in the Basin that they are covering now, do you have any notion?

MR. WRIGHT: No, we don't have any notion at this time. They are working on one side or expanding the pile at this time, so that is why they aren't working on the two sides at this time. But I don't know when the covering of the side slopes will be complete.

CHAIRMAN STEIN: How long have they been working?

MR. WRIGHT: Just a few months, just since Colorado got tough.

CHAIRMAN STEIN: Well, you have no idea or estimate of how long that might take?

MR. WRIGHT: No, I really don't. We are still in the process of considering our requirements, and one of our main points in the decision of the regulations is our time limit on how soon after an active pile becomes inactive will the cover be completed.

CHAIRMAN STEIN: Now, I can understand that. But here is a place where a construction job has already started.

MR. WRIGHT: Right.

CHAIRMAN STEIN: And generally speaking, when a construction job starts, just for keeping the men on the payroll and running cost estimates and doing business, you really generally have a pretty good notion when they are going to finish on this. That is why I asked.

MR. WRIGHT: In this case, though, it is not really construction job. They are using people that are not busy moving ore to move the fill material, so it is just an off-and-on situation when they have time to work on it.

CHAIRMAN STEIN: Right.

Are there any further comments or questions?

If not, may we hear from Wyoming.

MR. WILLIAMSON: Mr. Chairman, I do not have a prepared statement, but I think there are a few comments that I can probably make at this time.

In the State of Wyoming we do have six uranium mills, of which only one is inactive at this time. As you can see from the map over here, none of these mills fall within the Colorado River Basin. Our headache, if we ever have one, will be in the Missouri River Basin, because that is the drainage in which all of our mills are located.

As we said, five of these are still active mills, with only one inactive. Actually, the things we do here today will undoubtedly set a precedent which will probably be picked up and applied to other river basins, so that is why I feel possibly a comment or two is in order.

At the present time we feel that no real hazards are involved with the mines within our State. Some of this probably goes back to our original requirements. Luckily, most of our mills were built late in the uranium boom, they were all new mills, they had to come in to have their plans reviewed and approved, and we had a chance to say what we wanted.

We had some fairly simple ground rules. One of them was get as far from water and people as you can, and we were quite successful in getting them way out in the country. This solved a lot of problems.

The other ground rule was there would be no discharges of tailings or liquid wastes into any watercourse, stream, and so forth. In other words, we required complete detention of all wastes, including tailings, and I think this solved some problems.

As a result, we have nothing that is similar to the uranium tailings pile which you are speaking of here today where they build up this big mountain-sized pile. All of our wastes went into impoundments or to specially constructed impoundments. Consequently, we have a flat area with only the top of the tailings exposed. The berms, the dikes, the whole area was built up from native earth, so we have no side slopes on these things. They are a flat area. So actually we have very little to worry about in the way of erosion, wind carriage, and this type of thing.

We feel that most of our problems have been solved by the original construction, and, as we say, at this time they are so isolated that if there is anything blowing off of the top of these ponds, why, there isn't anything or anybody out there for it to bother. So about as much as we could foresee would be some type of thing to make sure that some of these impoundments which may be established in very small watercourses would not sometime in the future erode, say much as the original land surfaces did.

Three of these mills are located approximately 40 miles from permanent water and there are no people there. Two of them or one of them might be classed as being in close proximity to a community. The one at Riverton is built on the outskirts of that town. The one at Jeffrey City, which the only people there are the mining town really, is in a closed basin. Even if their original impoundment failed, it can never go anywhere and can never get to water. The other one in the Shirley Basin country is within, you might say, a short distance of a watercourse, probably within three or four miles of water, so it would be one that would have a possibility of reaching a stream if anything ever occurs. Actually, we cannot anticipate any all-out program at this time for control of disposal from these installations.

I think that is our situation.

CHAIRMAN STEIN: Thank you.

Any comments or questions?

Art, I think Wyoming has given us an example, and I have noted this through the years, with this uranium milling problem, **and** I suspect we can put this down in any kind of pollution control problem, that the best solution to pollution control, and this includes air and water pollution, is the original site selection. You can't beat it. Once you get down the bank of a river course in a narrow valley where you have no place for an effluent pile and no place to put a pile and that river is going to close up and have a freshet and run down, you are just fighting a bad problem. If you get into one of these spots, the site selection is the key to the solution.

I bring this up again because these industries, the uranium industry, the silver industry, other industries have a way of coming up again, and it seems that we should all profit the way Wyoming has profited by the experience and try to use some care in site selection and a few simple devices, and not have these exposed and built-up piles, and this will reduce the grief. I think the kind of foresight and prevention that was used in Wyoming in this problem is probably the best kind of pollution control and the one that gets the least amount of publicity, because you only really have a crisis and a problem in order to put it back. When the job is done well from the beginning, very few people notice it.

Thanks, Art.

May we go to Nevada. Mr. White.

MR. WHITE: There are no uranium operations in the Colorado River Basin in Nevada. The Colorado River interest of Nevada is in Lake Mead as a principal source of water supply to Las Vegas and the entire supply of water to Henderson and Boulder City. In addition to water supply, this is a major fishery and recreational source, including that of the Federal government. From now on, the growth of Clark County is dependent upon Lake Mead as a source of water. There are no alternate natural sources of supply for this area and there is a major development project for use of this water for drinking water purposes in excess of a hundred million dollars under way for Las Vegas at this time, so you can see this is important to us.

When this conference began, there was concern that Lake Mead was a repository for the sediments from uranium tailings. At this time increase in radiation levels has not been determined from this source. There have been, at different times, temporary radiation levels in the Lake Mead area resulting in emotional reactions to radiation levels of all kinds. Nevada is concerned, but appreciative of the Public Health Service, the Federal Water Pollution Control Administration particularly, the Colorado River group, and the many mining and milling operators upstream for their efforts and actions in protecting this source of supply.

It would appear that controls are the responsibility of milling operators' efforts to confine and control these wastes. This will be successful as long as there is profit in the product processed and there is ownership of mill tailings sites by a company with resources. When the profit in the product is gone, there could well be no control.

The immediate controls have been effective and there are immediate interim plans. We would like very much to see, because of the long half-life of the radioactive materials concerned, a control on a long-range basis. Believe me, we have mill operations and mining operations in our State, and once these have quit operating and there is no more profit, there is nothing more serious than this dead horse on the State's hands.

Thank you.

CHAIRMAN STEIN: Thank you, Mr. White.

Any comments?

I think those people in the Federal agencies can see one theme running through the State comments, and I think this is really going to be an issue that the Conferees are going to have to take up and we are going to have to consider.

May we go to California, Mr. Bonderson.

MR. BONDERSON: Mr. Chairman, Conferees, ladies and gentlemen.

We have no prepared statement since there are no milling operations in the California portion of the Basin. I would like to take this opportunity, though, to commend the various governmental agencies and the industry for the progress and good work that you are doing and hope that this continues in this direction as time goes on.

Thank you, Mr. Chairman.

CHAIRMAN STEIN: Thank you, Mr. Bonderson.

Any comment or question?

This concludes--

MR. THATCHER: Mr. Chairman.

CHAIRMAN STEIN: Yes.

MR. THATCHER: I wonder if I could pick up. I intended when I made my statement to ask if any of our invitees had statements to make. I am not aware that any of them do. We sent out nearly 300 notices, and so at this time I would like to invite any of the invitees from Utah to make any statement they have.

Apparently there are none.

CHAIRMAN STEIN: Let me again explain the ground rules. If anyone has a statement he wants to make, he should make his wishes known now, because this is going to conclude the statements and the Conferees will go into executive session. There will only be statements from the Conferees after the executive session, and I want to say this because this has come up before.

The reason for this is plain. Once we have the executive session and we make a determination, any material coming in from you will not be considered or folded into the executive session, so we are going to proceed on the views, the data, and the material before the Conferees now.

Now, I have been told that in order to be realistic about reconvening back here after lunch that we had better consider having an hour and a half for lunch, otherwise we are not going to make it. The executive session will be in Room 208. I have about 5 to 1. That will put it about 25 after 2. I would suspect that the Conferees should be able to have a statement in this room sometime between 3:30 and 4. Is that fair enough or do you think we are going to have to take longer?

So we will recess for lunch. The Conferees will reconvene about 2:25 in Room 208 of this building and we will appear here again between 3:30 and 4 with an announcement.

(Noon Recess)

AFTERNOON SESSION, JULY 26, 1967

CHAIRMAN STEIN: May we reconvene?

I am happy to announce that the Conferees involving the seven States and the United States Department of Interior have arrived at unanimous conclusions and recommendations. I extend my congratulations to all the Conferees for this give and take, because you all know the formidable task you face when you get eight different agencies trying to come up with an agreed-upon statement, but I think we have made it.

These are the recommendations and conclusions of the Conferees:

(1) The Atomic Energy Commission, Department of Health, Education, and Welfare, and the United States Department of the Interior shall be responsible for jointly developing, as soon as possible, a long-range program for the protection of the environment from uranium mill tailings. The program is to be developed in cooperation with the concerned State and Federal agencies and submitted to the Conferees in six months.

(2) Uranium mill inactive tailings piles shall be contained and structurally stabilized to prevent wind and water erosion and leaching. Active tailings piles shall be managed to minimize such erosion

and leaching during use.

(3) The immediate planning, management and containment of the piles is the responsibility of the individual owners subject to the regulation of the appropriate State agency. The AEC as a major purchaser is to assume its responsibility in this activity.

(4) The primary responsibility for enforcing the necessary stabilization and containment of uranium mill tailings piles for both short-range and long-range programs rests with the States concerned.

(5) The short-range remedial programs consisting of the necessary stabilization measures to prevent wind and water erosion and leaching at active and inactive piles in the Colorado River Basin shall be completed by the end of 1970.

(6) Reasonably uniform State requirements and implementation programs for the control of tailings piles are desirable in the Colorado River Basin.

(7) The surveillance activities performed by State and Federal agencies shall be continued for the purpose of providing a continuing evaluation of the adequacy of control measures in terms of the short-range and long-range environmental radioactivity levels.

We will have copies of the recommendations and conclusions duplicated, and I hope we will be able to make a limited distribution. That should be done in a few minutes if you wish to wait.

Do any of the Conferees wish to add anything to this at the present time?

If not, I would like to thank the Conferees for coming. I think this is a milestone culminating--I don't know that it is culminating, because these problems are always with us, but it is another milestone in the environmental protection of the Colorado River Basin, and I would like to thank all of the States for their cooperation, thank the HEW and the Atomic Energy Commission. More and more I think we are truly arriving at a joint Federal-State industrial program, and I would like to thank the industry for its continued cooperation. I think we are practically operating as one big staff now, and progress is coming a lot easier and I think we are all beginning to see each other's points of view.

With that, thank you all, and we stand adjourned for six months.

(Adjournment)

APPENDICES

Appendix A

Disposition and Control of Uranium Mill Tailings Piles in the Colorado River Basin - March 1966, by U. S. Department of Health, Education, and Welfare, Federal Water Pollution Control Administration, Region VIII, Denver, Colorado

Appendix B

A E C Licensing Guide, Information and Criteria Pertinent to Evaluation of Embankment Retention Systems, by U. S. Atomic Energy Commission, Source and Special Nuclear Materials Branch, Division of Materials Licensing, Washington, D. C.

Appendix C

Agreement, Joint Federal Agency Position Regarding Control of Uranium Mill Tailings - December 8, 1966, among U. S. Atomic Energy Commission, U.S. Department of Health, Education, and Welfare, and the U. S. Department of the Interior

109

APPENDIX A

DISPOSITION AND CONTROL OF URANIUM MILL TAILINGS PILES IN THE COLORADO RIVER BASIN

WYOMING
Cheyenne
NEVADA
Salt Lake City
Denver
UTAH
COLORADO
Santa Fe
ARIZONA
NEW MEXICO
CALIF
Phoenix
MEXICO

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Federal Water Pollution Control Administration, Region VIII
Denver, Colorado

March 1966

URANIUM MILL LOCATIONS
IN THE
COLORADO RIVER BASIN

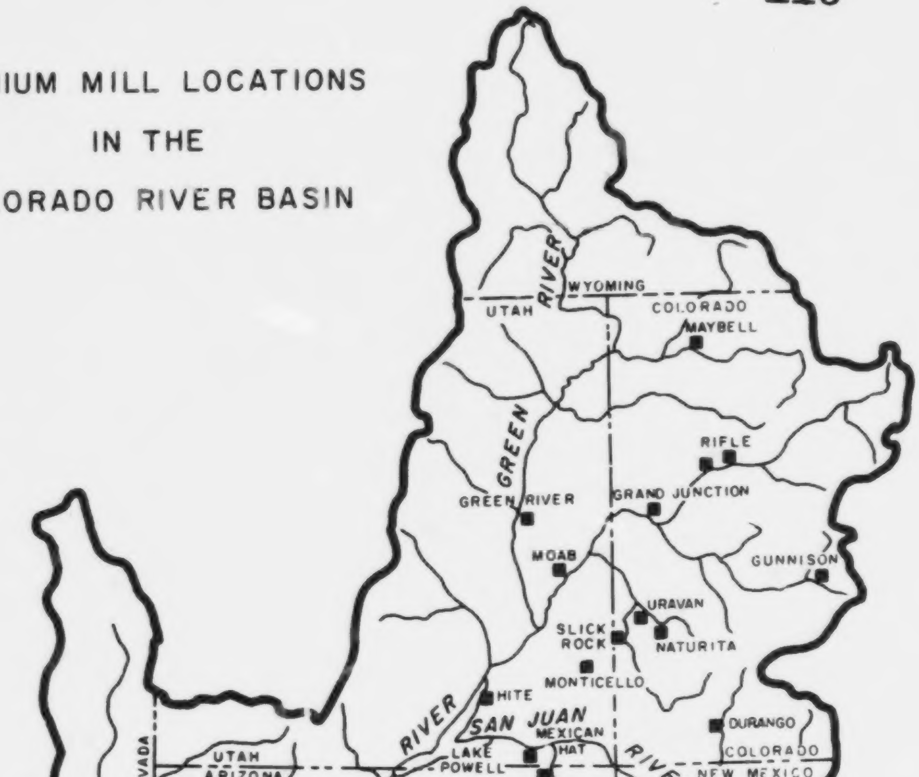

GREEN RIVER
WYOMING
UTAH
COLORADO
MAYBELL
GREEN
RIFLE
GREEN RIVER
GRAND JUNCTION
MOAB
GUNNISON
URAVAN
SLICK ROCK
NATURITA
MONTICELLO
HITE
RIVER
SAN JUAN
MEXICAN HAT
DURANGO
LAKE POWELL
RIVER
COLORADO
NEVADA
UTAH
ARIZONA
NEW MEXICO
MONUMENT VALLEY
SHIPROCK
COLORADO
TUBA CITY
LAKE MEAD
LITTLE COLORADO RIVER
CALIFORNIA
ARIZONA
GILA RIVER
ARIZONA
NEW MEXICO
ARIZONA
MEXICO

TABLE OF CONTENTS

Page

PREFACE i

PURPOSE 1

BACKGROUND 3

SUMMARY AND RECOMMENDATIONS 7

DISCUSSION 9

TAILINGS PILE CHARACTERISTICS AND CONTROL METHODS 22

ESTIMATED COSTS OF CONTROL METHODS 26

BIBLIOGRAPHY 35

APPENDIX . . . . A-1 - A-28

Photographs, Descriptions, and Control Suggestions for Colorado River Basin Uranium Mill Tailings Piles

Rifle (Old Mill) A1, A2
Naturita A3, A4
Slick Rock A5, A6
Maybell A7, A8
Gunnison A9, A10
Durango A11, A12
Mexican Hat A13, A14
Green River A15, A16
Monticello A17, A18
Rifle (New Mill) A19, A20
Uravan A21, A22
Grand Junction A23, A24
Moab A25, A26
Shiprock A27, A28

PREFACE

This report on the dispostion and control of uranium mill tailings piles in the Colorado River Basin reflects the concern of the Federal Water Pollution Control Administration with all aspects of the various radiochemical waste sources which have a potential for pollution of Colorado River Basin waters, one of the West's most vital resources. The position of the Federal Water Pollution Control Administration (FWPCA) with respect to the ultimate disposal of uranium mill tailings piles is as follows:

The problem of ultimate disposal of uranium mill tailings was first mentioned at the Fourth Session of the Conference in the Matter of Pollution of the Interstate Waters of the Colorado River and its Tributaries, held at San Diego, California, May 27, 1963. At that time the following was the total statement made on this subject by the Division of Water Supply and Pollution Control of the Public Health Service:

> "Finally, it appears that we have reached a point at which the problem of ultimate disposal of uranium mill tailings should be given more serious consideration. Their radioactivity is very long-lived. Occasional questions as to their suitability for land-fill operations and for highway subgrade material have gone unanswered. Field studies are not proposed at this time, but rather it is proposed that the industry as well as the responsible local and Federal agencies attempt to develop a rational approach to the long-term protection and containment of tailings piles as well as rational evaluation of proposals for their possible disposal by uses such as those noted above."

The above statement represents the position of the FWPCA in regard to the problem of ultimate disposal of uranium mill tailings. At the Fifth Session of the Conference in the Matter of Pollution of the Interstate Waters of the Colorado River and its Tributaries, held in Las Vegas, Nevada on May 27, 1964 further clarification in this position was given as follows:

> ". . . to determine the degree of hazard associated with these tailings piles is no simple problem. If you think in terms of immediate hazards, or in terms of hazards this year, it is very difficult to show that there is a problem. What has concerned us right along has been the long-lived nature of the radioactivity involved."

The FWPCA wishes to emphasize that it is not especially concerned regarding immediate hazards from abondoned uranium mill tailings. Rather, the Administration is concerned with the potential problems that appear to be associated with the tailings because of their extremely long-lived radioactivity.

The FWPCA wishes to stress the need to regard the tailings piles on an individual basis, because of the widely different environmental circumstances that are associated with each tailings pile. In addition, it is emphasized that specific proposals for the disposition of these tailings, such as for example, their use as subgrade material for highway construction, their possible use for land-fill, etc., must also be studied on an individual basis because of the specific environmental circumstances that may be involved. Each tailings pile location and each specific proposal for disposition must be judged on its own merits, and it is highly unlikely that sweeping or general recommendations that apply to all tailings can be made.

DISPOSITION AND CONTROL
OF URANIUM MILL TAILINGS PILES
IN THE COLORADO RIVER BASIN

PURPOSE

In addition to the more usual organic and inorganic liquid waste disposal problems encountered at many industrial installations, the uranium milling industry produces large quantities of solid wastes in the form of radioactivity laden sand tailings pile material. This report has been prepared by the Colorado River Basin Water Quality Control Project at the direction of the Chairman, Conference in the Matter of Interstate Pollution of the Colorado River and its Tributaries. Its purpose is to evaluate the radioactivity content of uranium mill tailings piles in the Colorado River Basin, to evaluate their radioactivity water pollution potential insofar as this is possible, and on a case-by-case basis, to indicate feasible and desirable remedial measures for controlling and limiting the spread of radioactivity from the piles.

In addition to the radiological pollution potential, the tailings piles also present a potential source of mineral pollution and physical degradation. This phase is being studied within the overall pollution investigation program being conducted by the Colorado River Basin Water Quality Control Project and will be considered in a separate report.

Other uranium mill tailings pile studies have recently been undertaken by the Public Health Service, Division of Radiological Health to investigate air carriage (wind erosion) of tailings material to nearby communities and the resulting community impact from any environmental radioactivity increases. The first phase of these studies involved the use of gummed paper trays placed in the vicinity of tailings piles to obtain a qualitative indication of air transport of tailings material to surrounding communities. In the second phase, air filter sampling was utilized to obtain quantative information on the air radioactivity problem in several communities where uranium mill tailings piles are located.

The studies have demonstrated definite wind transport of radioactive tailings material from the tailings piles to surrounding community areas. No firm conclusion can be drawn regarding long-term potential hazard from the preliminary findings thus far developed. Therefore, the Division of Radiological Health is planning additional intensive study to define more exactly the existing and potential radiological effects of long-term transport of tailings material into the community environment. The information obtained by this study, when it becomes available, will assist in evaluating the environmental effects of the tailings piles.

The Atomic Energy Commission has also conducted studies of several tailings piles in the Colorado River Basin, including the pile at Monticello, Utah where the Commission undertook an extensive tailings pile control program of shaping, earth covering, and seeding in 1962. A recent Commission report[1] on an AEC evaluation of radiological conditions at the Monticello site reflects the desirability for tailings control measures and the need for consideration of the potential hazards from movement of tailings material into the environment. In evaluating the suitability of the covered Monticello tailings pile for occupancy by the general public, the report states:

> "Surface occupancy can be permitted on a nonrestricted basis; however, the presence of subsurface contaminants at the tailings area require control, as any disturbance of existing terrain could materially change the radiological conditions found at the time of this survey."

---

[1] Paas, Herman J., Jr., Radiological Appraisal of the Monticello Project, San Juan County, Monticello, Utah, Idaho Operations Office, U.S. Atomic Energy Commission, February 1966.

BACKGROUND

Since the early 1940's, uranium ore production has grown to a major industry in the Colorado plateau country of the western United States. Some of the more extensive ore deposits are located in the Colorado River Basin, with 12 uranium processing mills and 5 uranium concentrators having been in operation at one time or another in the Basin. At the end of 1961, when all but two of these mills were in simultaneous operation, they had an aggregate design processing capacity of 6,650 tons of uranium ore per day (1).

Beginning in 1955, the problem of releases of radioactivity to the water environment from operating mills was recognized (2), and a positive cooperative program of pollution control on the part of the uranium milling industry, the states, the Atomic Energy Commission, and the Public Health Service has been successful in reducing surface water radioactivity to very low levels within the Colorado River Basin.

The continued production of uranium concentrate has resulted in the accumulation of uranium mill tailings piles in sizes ranging from several thousand to several million tons of material at various locations in the Basin. As production rates began to decrease in the early 1960's due to reduced demand for uranium, individual milling companies began discontinuing operations and closing down mill sites. In cases where adequate containment facilities were not provided for tailings pile material, the tailings piles have been left exposed to erosive action by wind and water. The resulting potential for the spread of radioactive material into the streams and communities has raised an important question as to methods and costs of ultimate disposition and control of these tailings piles. This report discusses the problem of surface water radioactivity contamination from tailings piles at nonoperating uranium mills in the Colorado River Basin insofar as present knowledge permits such evaluation, and presents a cost analysis of suggested tailings pile control measures at these mills. The report also presents an observation of existing and potential pile erosion problems which may be encountered at operating uranium mills in the Basin.

It should be emphasized at the outset that insofar as radioactive surface water quality is involved, we are concerned primarily with long-term rather than immediate hazards. Data obtained from the Radioactivity Monitoring Network operated by the Project demonstrates that the water pollution control measures practiced by the industry at operating mills have been very effective and there is currently no significant immediate hazard associated with uranium milling activities anywhere in the Colorado River Basin. However, much of the radioactivity contained in the mill tailings is very long-lived -- for instance radium-226 has a half-life of 1620 years, and thorium-230 has a half-life of 80,000 years, to mention two of the more important potential contaminants in the tailings (see Figure 1 and Table 1). It is known that the radium-226 contained in the tailings is leached and becomes dissolved in flowing water. Although similar studies have not been made for the other isotopes involved, the present state of knowledge indicates that radium-226 is probably the isotope of most concern.

It is the very long-lived nature of the radioactivity that makes necessary a cautious attitude toward the problem of ultimate disposition of mill tailings. The total of 3,000,000 tons of tailings that exist at the seven closed mills listed in Table 3 contain about 2,000 grams of radium-226 alone. This tonnage represents less than one-fourth of the total amount of uranium mill tailings currently piled in the Colorado River Basin at all nonoperating and operating mills. In terms of currently accepted permissible limits in water and in terms of natural background levels of radium-226, this represents a very large quantity of radium-226 and other radionuclides.

Radium-226 has been demonstrated to be the major factor in causing radioactivity increases in tailings affected streams, and the addition of these other radionuclides to the overall contaminant picture and the documented transport of the radioactivity into the environment and the food chain (3) provide combined reason for serious consideration of the tailings control problem.

It is impossible to predict the changes that may occur over centuries that may effect or alter the importance of the tailings as an environmental contaminant. It appears likely that major changes in river hydrology, both natural and man-made, may occur to change the character, courses and uses of Basin surface waters. Locations that are now remote and barren can become population centers. The general radioactivity "background" exposure level, composed of both natural and fallout sources, may well increase slowly but definitely over the decades. The experience of the past two or three decades regarding allowable exposure to radium-226 indicates clearly that standards for radiation protection are not stable but can be expected to change (their general trend has been downward in recent times), and at least one authoritative source (4) has indicated that even the smallest general radiation dose has an associated risk, and has recommended that the population permissible dose from man-made sources, exclusive of medical and dental uses, be limited to one equivalent of natural background radiation dose. Although this latter recommendation refers to large populations and areas, rather than to small population groups, the Colorado River, one of the great rivers in America, includes an extensive tributary land area and even now serves a substantial population. In several cases, such as at Durango, Grand Junction, and Gunnison, Colorado, the uranium mill tailings piles are immediately adjacent to population concentrations. In many other cases, tailings piles are less than two miles from population concentrations. It is suggested, therefore, that the above permissible dose recommendation gives us an indication of the potential long-term significance of the tailings.

In its discussion of minimum radiation exposures in the National Bureau of Standards Handbook 69 (5), the National Committee on Radiation Protection recommendation on the Maximum Permissible Concentration (MPC) of radionuclides in air and water states:

> "There remain many serious uncertainties in the basic biological data on which the calculations (of MPC and body burden values) are based and thus it is necessary again, as in earlier handbooks, to urge that all exposures be kept to the minimum practically obtainable."

The Federal Radiation Council (6) has stated this principle of minimum exposure in terms of the benefit vs. risk philosophy of the International Commission on Radiological Protection (7), as follows:

> "There can be no single permissible or acceptable level of exposure without regard to the reason for permitting the exposure. It should be general practice to reduce exposure to radiation, and positive effort should be carried out to fulfill the sense of these recommendations. It is basic that exposure to radiation should result from a real determination of its necessity."

SUMMARY AND RECOMMENDATIONS

The foregoing discussion indicates clearly a need for caution and a conservative approach to the problem of disposition and control of uranium mill tailings. In view of study results discussed herein, which demonstrate radioactivity increases resulting from uranium mill tailings pile material reaching the Colorado River Basin surface waters and which indicate potential effects at almost every mill in the Basin, control measures to prevent substantial movement of tailings to streams and the surrounding environment require serious consideration. The estimated costs for control, reported later, prove to be quite small in most cases when compared to the $28,803,035 received in 1964 for uranium concentrate by the mills then operating in the State of Colorado (8).

The question of long-term public and private responsibility for adequate control and disposition of the abandoned tailings has not yet been resolved, but must eventually be answered. Meanwhile, although no immediate hazard is apparent, relatively casual uses of small quantities of tailings for various local uses have been reported or proposed, and there is definite evidence of wind distribution of, as yet, relatively small quantities of tailings in communities. There is evidence also that once they become a part of the stream environment, the tailings constitute a relatively long-term source of dissolved radium-226.

On the basis of the foregoing considerations, the Colorado River Basin Water Quality Control Project submits the following recommendations:

(1) That interim measures to prevent the erosion and spread of uranium mill tailings be undertaken without undue delay.

(2) That all distribution of mill tailings from either nonoperating or operating mills be halted until proper and adequate precautionary review procedures can be instituted.

(3) That, in view of the very long-lived nature of the radioactivity involved and the long term potential for pollution of Basin waters, discussions be held and binding agreements be reached as soon as possible regarding long term public and private responsibility for adequate maintenance of the tailings piles.

By "interim" measures in the first recommendation is meant measures that will prevent significant spread for say 10 to 20 years. Such a program, while not excessive in cost, would provide time during which some of the foregoing questions as to river hydrology, standards, responsibility, etc., may be partially answered. Suggested "interim" measures include covering tailings piles with either dirt or a petroleum product stabilizer, seeding, and building dikes to protect the piles from river erosion. These measures are described on pages 26 through 34.

The above recommendations are not intended to discourage or prevent the use of mill tailings. To the contrary, the Project hopes that during such an interim period, beneficial uses that incorporate adequate disposition will develop. In any case, the aforementioned considerations suggest there is little justification for tailings piles to be simply abandoned to weather and spread indiscriminately and indefinitely.

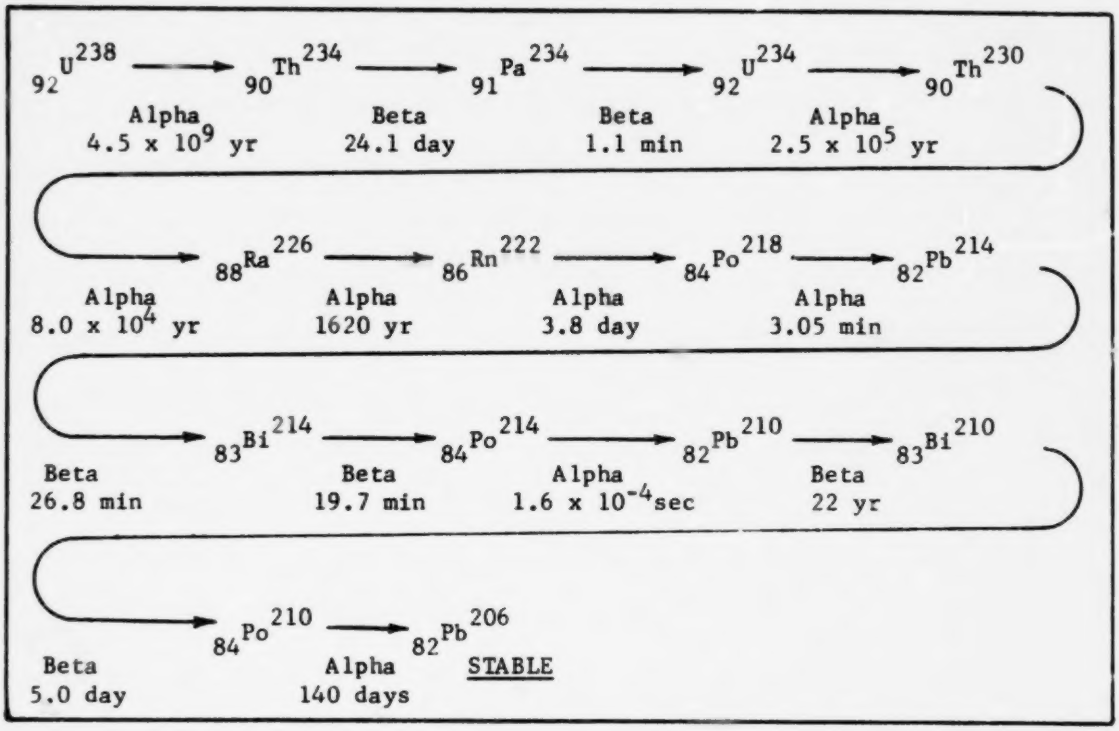
It should be noted that this report and the above recommendations refer primarily to the tailings piles at nonoperating uranium mills, although the principle and remarks apply to all operating and nonoperating mills in the Basin.

DISCUSSION

In the uranium-bearing ore, as it is delivered to the mills, the uranium content generally averages about 0.25 percent as U_3O_8 (uranium oxide). This is present as uranium-238 and uranium-235, both of which are naturally occurring radioactive parents of long chains of radioactive daughter products. Natural uranium contains about 99.28 percent uranium-238 and 0.71 percent uranium-235 (9); hence, the decay chain of uranium-238, known as the uranium-radium family, is of primary importance in uranium mill tailings. The radioactive decay scheme of this chain is shown in Figure 1. Two minor branches occur in the chain, but are not shown since their potential effect is negligible.

The majority of ores contain this radioactive family in secular equilibrium, i.e., the daughter products are being formed at the same rate at which they are decaying, with the amount of any member actually present remaining constant. Each pound of uranium contained in the ore has an alpha activity of 150 microcuries (μc) and, since this is also the activity level of each of the 13 daughter products shown in Figure 1, the total combined alpha and beta radioactivity of the average ore is 2,100 microcuries or 2.1 millicuries (mc) per pound of uranium. As the ore passes through the milling process, some 85 percent of this activity becomes mill waste, the remainder being recovered in the uranium concentrate product (10).

Generally one to three percent of the ore input is dissolved in the milling process, which means that one ton of ore contributes 20 to 60 pounds of dissolved solids to liquid waste streams. Solids leaving the mill as uranium concentrate product account for but five pounds per ton of ore



$_{92}U^{238}$
Alpha
4.5 x 10^9 yr
$_{90}Th^{234}$
Beta
24.1 day
$_{91}Pa^{234}$
Beta
1.1 min
$_{92}U^{234}$
Alpha
2.5 x 10^5 yr
$_{90}Th^{230}$
Alpha
8.0 x 10^4 yr
$_{88}Ra^{226}$
Alpha
1620 yr
$_{86}Rn^{222}$
Alpha
3.8 day
$_{84}Po^{218}$
Alpha
3.05 min
$_{82}Pb^{214}$
Beta
26.8 min
$_{83}Bi^{214}$
Beta
19.7 min
$_{84}Po^{214}$
Alpha
1.6 x 10^{-4}sec
$_{82}Pb^{210}$
Beta
22 yr
$_{83}Bi^{210}$
Beta
5.0 day
$_{84}Po^{210}$
Alpha
140 days
$_{82}Pb^{206}$
STABLE

Figure 1. URANIUM - RADIUM FAMILY - Minor branches not shown

(0.25 percent), therefore all but a small fraction of ore input leaves the mill as waste solids, or tailings.

Since these undissolved solids contain the bulk of the radium and other radioisotopes originally present in the ore (1), the disposition and control of the solid wastes to prevent their distribution through the environment by wind and water erosion to nearby streams and communities is a very significant aspect of the total uranium milling waste disposal problem.

The gross radioactivity of the mill waste material is attributable to each member of the uranium-radium family originally present in the ore. The relative degree of hazard presented by the various isotopes shown in Figure 1 covers a wide range. Table 1 lists each of them in order of increasing recommended maximum permissible concentrations in water (MPC_w values), or decreasing degree of hazard. The first isotope listed, radium-226, has an MPC_w of only 3.3 picocuries per liter (pc/liter). This is the lowest MPC_w of any of the 264 isotopes considered by the National Committee on Radiation Protection (5) and the International Commission on Radiological Protection (7).

Due to the very low MPC_w and the long half-life on radium-226, this isotope has been of prime importance in the analysis of uranium milling wastes, and in the specific problem of long-term containment and control of these wastes.

The radium remaining undissolved during ore passage through a mill comprises all but one or two percent of that entering the mill and is found in the solid ore tailings discarded by the mill as waste Since the majority of the radium is contained in the tailings, if these solids are permitted to enter a stream and accumulate on the stream bed, the radium can then be leached from these solids to the overlying waters A report published in 1960 (3) cites a case of an operating mill where this effect has been observed to result in a dissolved radium concentration downstream from the mill of 12 picocuries per liter--about four times the MPC_w, and more than 20 times higher than would be expected on the basis of the dissolved radium discharged by the particular mill to the stream. Tailings associated radium levels of twice MPC_w levels were noted as far as 30 miles below the mill, and near MPC_w levels as far as 60 miles below the mill (3).

Table 1. URANIUM-RADIUM FAMILY, MPC_w VALUES[1/]

Isotope	MPC_w pc/liter	Critical Organ	Half-life	Emission
Ra^{226}	3.3	Bone	1,620 yr	Alpha
Pb^{210}	33	Kidney	22 yr	Beta
Po^{210}	233	Spleen	140 day	Alpha
Th^{230}	667	Bone	8×10^4 yr	Alpha
Th^{234}	6,667	GI tract	24.1 days	Beta
U^{234}	10,000	GI tract	2.5×10^5 yr	Alpha
U^{238}	13,300	GI tract	4.5×10^9 yr	Alpha
Bi^{210}	13,300	GI tract	5 days	Beta
Pa^{234}	2/	-	1.1 min	Beta
Po^{218}	2/	-	3.05 min	Alpha
Po^{214}	2/	-	1.6×10^{-4} sec	Alpha
Bi^{214}	2/	-	19.7 min	Beta
Pb^{214}	2/	-	26.8 min	Beta
Rn^{222}	(gas)	Lung	3.8 days	Alpha

1/ MPC_w value is the maximum permissible concentration in water for average member of the general population (1/30th HB69 value for continuous occupational exposure).

2/ No value given for these short-lived materials.

Detailed laboratory studies have been conducted on the leaching of radium-226 from uranium mill waste solids and river sediments (11) and have shown that from as little as 0.10 percent to as much as 40 to 50 percent of the total radium associated with the solids can be leached by water.

These studies indicated two factors which greatly influence the quantity of radium-226 leached from waste solids: (1) the quantity of solids (or total radium reservoir) available for leaching, and (2) the liquid-to-solid ratio (ml/gm) for a given quantity of solids. The greater the quantity of solids available, the greater the quantity of radium leached, and the higher the liquid-to-solid ratio, the greater the quantity of radium leached.

The fines present in a tailings pile are the most difficult to control and are more easily carried away by surface runoff from the pile. They also contain the most radium per unit weight (11). Because of their small size and the high liquid-to-solid ratio which exists, significant radium can be leached when these solids enter a stream with high flow. These fines are considered a major factor in the contribution of dissolved radium to a stream.

Another important leaching factor is time. Under laboratory conditions, the maximum amount of radium was shown to be leached from tailings solids within a few minutes. A similar time relationship is probably encountered in a river, although here a continuing readsorption-releaching process takes place, which eventually places most of the leachable radium into dissolved form in the river water (12).

After radium-bearing solids have entered a river they mix with the stream sediments and are eventually transported downstream to a place of final deposition, such as the Lake Powell and Lake Mead reservoirs. This transport of radium contaminated sediments has been documented by sampling of Lake Mead bottom sediments which have shown radium-226 concentrations of three times the background levels found in Basin stream reaches above uranium milling operations and below the Lower Basin reservoirs (1)(12)(13). These increases in the radium content of sediments are associated with a small increase in the dissolved radium content of the overlying waters. However, the dissolved radium level in the Lower Basin reservoirs has not approached unsafe levels.

Table 2 presents historic and more recent sediment radium and associated water radium levels found downstream from sources of uranium milling waste discharges. As mentioned earlier, the improvement in waste controls enacted since 1955 have reduced contamination to low levels, as is shown. The contrast between radium levels in river sediments before and after the institution of control measures or mill shutdown can readily be seen.

The long term effects of waste tailings in streams is also apparent from Table 2. The Animas River sediments continue to exhibit radioactivity above background levels and South Creek sediments exhibit high radium levels even though the upstream mills have ceased operations. Following institution by the AEC of a tailings control program at the Monticello Mill on South Creek in 1961 (diking, earth cover, and grassing), water and sediment radium levels began to decrease to the current values shown in the table.

Data from the San Miguel River collected in 1955 showed dissolved radium concentrations as high as 88 picograms per liter (pg/liter) (2). Although, in that case, there may have been some significant direct effluent release of dissolved radium, the bulk of the 88 pg/liter undoubtedly resulted from leaching of extensive river bed tailings deposits that contained as much as 2,100 picograms per gram (pg/gram) of radium-226.

Table 2. RADIUM-226 IN RIVER SEDIMENT AND WATER

River	Radium in Water pg/liter	Radium in Sediment pg/gram
Background Stations[1]	0.05 (0.01-0.16)	1.1 (0.3-1.8)

River	Miles below mill	Water Radium pg/liter	Sediment Radium pg/gram	Date of Sample
Animas River (Mill closed 1963)	2	13	115	Summer 1958
		24	600	April 1959
		0.2	4.4	August 1961
		0.3	1.9	September 1962
		- -	2.0	March 1965
South Creek (Mill closed 1961)	1	27	202	November 1961
		5.1	160	April 1962
		4.6	67	June 1962
		6.6	144	October 1962
		6.2	63	March 1963
		1.4	75	January 1964
		3.6	99	December 1964
San Miguel River (Mill closed 1963)	1	1.2	7.9	August 1960
		0.15	3.0	December 1964

---

[1] Stations upstream from uranium mining and milling operations

In order to obtain an idea of possible radium concentrations which may exist in river water in the event of a large volume of tailings material gaining access to a river, a hypothetical case can be evaluated with some assumptions of the various factors involved.

As will be noted later, the tailings pile at Durango, Colorado, is located adjacent to the Animas River and piled in such a manner that if a major structural failure of the pile occurred (one small failure of this type has been observed), a large volume of tailings could slip into the river. The Durango tailings contain about 900 picograms of radium per gram of material.

The following tabulation can be prepared by assuming several possible conditions: One to ten tons slipping into the river and resulting in a high liquid-to-solids ratio; various leaching rates for a one-hour period; and, a low river flow of 300 cubic feet per second.

Tailings being leached	River Water Radium Concentration (pg/liter) [1/]		
	25% leach	10% leach	1% leach
1 ton	7	2.8	0.3
2 tons	14	5.4	0.5
3 tons	20	8.2	0.8
4 tons	27	11	1.1
5 tons	34	14	1.4
10 tons	70	28	2.8

1/ Neglecting background of about 0.05 pg/liter

The actual river concentration obtained would undoubtedly vary somewhat from those in the above table, but a 10 percent leach rate during the first hour does not appear unreasonable, based on the studies discussed earlier. The figures should provide a suitable estimate of the magnitude of initial radium concentrations that might be expected in the water if a small amount of tailings did enter the river. It is not unlikely that a much larger quantity of tailings could be involved in a major slide of the Durango tailings, and with the river at even lower flows, greater concentrations would develop.

To obtain an idea of longer term effects from another hypothetical slide at Durango, consider the following example: For a period of low flow, such as 200 cfs from October through March, assume various amounts of tailings reached the river, 10 percent of the available radium being uniformly leached in the first 5 days, and another 60 percent leached uniformly through the following 175 days*. These parameters produce the following tabulation:

Tailings reaching the river	River Water Radium Concentration (pg/liter)[1/]	
	During first 5 days	During next 175 days
40 tons	1.5	0.23
80 tons	3	0.46
120 tons	4.5	0.69

[1/] Neglecting background of about 0.05 pg/liter

---

* Up to 50% leach rates were noted earlier in this report. These were based on a 6-day leaching period. With longer term leaching, it is estimated that up to 60 or 70 percent of the total radium in the solids could be leached.

In both of these examples only a linear leaching rate is assumed, which is a conservative assumption. However, the figures do indicate that significant dissolved radium concentrations could result from leaching of tailings.

The hydrologic factors of sediment distribution and radium readsorption and releaching turn these seemingly short-term effects into a long-term consideration. This can best be demonstrated by two existing situations in the Colorado River Basin.

At Monticello, Utah, considerable tailings material was distributed through South Creek before a tailings control program was enacted to curtail this distribution. As shown in Table 2, even after tailings movement to the stream was eliminated, residual contamination levels continue to exist and are decreasing at a slower and slower rate. If a single volume of tailings was released at another tailings pile location in the Basin, similar long-term contamination might well result.

The tailings pile at Naturita, Colorado, is subject to essentially continuous movement into the San Miguel River by wind and water erosion. Although the amount reaching the river at any one time is small, sediment radium levels downstream from the pile average three times levels above the pile, and resultant water radium levels are also about three times levels found above the pile. Again, if larger amounts of tailings were to be eroded here or elsewhere, radioactivity levels would be expected to rise accordingly.

Three other isotopes listed in Table 1 have sufficiently long half-lives to warrant consideration in the evaluation of overall contamination from tailings material. They are thorium-230, lead-210, and uranium.

Since uranium recovery is the object of the milling process, relatively little uranium is contained in the tailings material. Some of this remaining uranium would undoubtedly be leached from the solids upon entering a river, adding to the total dissolved radioactivity, but because of its high MPC_w, it is considered relatively unimportant.

Significant amounts of thorium-230 and lead-210 are present in tailings pile material (Table 3). No data are available on early concentrations of these two isotopes in stream water and sediments below mill discharges, and relatively little is known about their movement from stream-carried solids to the overlying water. In general, these two isotopes will probably remain in undissolved form in the stream environment, unless stream conditions change (such as pH change) in a manner conducive to bringing either isotope into solution.

Using the tailings pile located at Naturita as an indicator of possible stream effects from these two isotopes, sediment sampling has shown an increase in lead-210 levels below the pile of about twice levels found upstream, and increases in thorium-230 levels by a factor of six to eight. The resulting concentrations are still well below MPC values and create no concern as regards immediate hazards. As with radium, the long-term hazard is not so readily ignored.

In addition to the sediment and water effects from the presence of uranium mill waste solids in a stream, other associated effects have been illustrated by earlier data (3). Analytical results have indicated that, on the average, crops raised on farms that were irrigated by Animas River water contaminated by discharges of radium-carrying ore solids contained twice as much radium-226 as did similar crops irrigated upstream with uncontaminated water. Certain crops such as hay and alfalfa have shown a much stronger tendency to concentrate radium, and concentrations many times higher than natural background have been observed at other farms in the Colorado Basin. Samples of aquatic biota (algae, insects, and fish) also indicated uptake and concentration of radium-226.

In addition to these surface water effects, still another aspect of pollution potential from the tailings piles is that of possible ground water contamination. Contamination of underground water can provide a source of pollution for both surface waters and individual and community domestic water supply wells. Such contamination is possible, even in regions of light precipitation, where the soil at the base of a tailings pile is saturated continuously or intermittently (14). Saturated conditions are likely to occur in the flood plains of streams where, in fact, several Basin tailings piles are located. In such circumstances, investigations of the potential for ground water contamination is indicated.

Although this matter has not been studied in detail in the Basin, sampling data have indicated definite effects at several locations. Industry-owned observation wells in the near vicinity of tailings piles and uranium mills have been reported to indicate radiation levels well above background. Since ground water usually travels at an extremely slow rate, areas that now appear normal may become contaminated later, and once contamination is accomplished, many years would be required to correct the situation. One example is a private artesian well (currently not used domestically) near the earth and grass covered Monticello, Utah, tailings pile. This well water contains dissolved radium-226 levels of about 4 pg/liter, slightly above Public Health Service Drinking Water Standards (15). As the radium levels in nearby South Creek have slowly decreased over the years, since the Monticello tailings pile control measures were instituted, the yearly well water samples have indicated essentially constant levels.

Although contamination may not be currently apparent, future contamination of underground waters may occur some distance from a pile when the ground water aquifer is recharged by a stream that has been affected by tailings, such as the San Miguel River in Colorado.

Measures to minimize seepage of water and liquids through tailings piles to the ground water aquifer were taken before tailings pile construction at one mill in the Basin. The Gunnison, Colorado, tailings pile base was lined with bentonite by the Gunnison Mining Company, and to date, no radioactivity contamination of the nearby ground water aquifer has been reported. All other piles in the Basin rest directly on the underlying earth, although not all have potential of contaminating ground waters used domestically.

TAILINGS PILE CHARACTERISTICS AND CONTROL METHODS

Of seventeen uranium mills (12 processing mills and 5 concentrators) located in the Colorado River Basin, ten have now discontinued operations, leaving tailings piles at each location. The mill locations are as follows:

Operating Mills

Climax Uranium Company, Grand Junction, Colorado
Union Carbide Corporation, Rifle, Colorado
Union Carbide Corporation, Uravan, Colorado
Vanadium Corporation of America, Shiprock, New Mexico
Atlas Corporation, Moab, Utah
El Paso Natural Gas Company, Tuba City, Arizona
Vanadium Corporation of America, Monument Valley, Utah (concentrator)

Nonoperating Mills

Union Carbide Corporation, Rifle, Colorado
Union Carbide Corporation, Maybell, Colorado
Kerr-McGee Oil Industries, Gunnison, Colorado
Vanadium Corporation of America, Durango, Colorado
AZ Minerals, Mexican Hat, Utah
Atomic Energy Commission, Monticello, Utah
Vanadium Corporation of America, Hite, Utah (concentrator)
Union Carbide Corporation, Green River, Utah (concentrator)
Union Carbide Corporation, Slick Rock, Colorado (concentrator)
Vanadium Corporation of America, Naturita, Colorado (concentrator)*

In August and November 1963, tailings samples were collected at seven closed mills and analyzed for radioisotope content. At the same time, stadia surveys were made to obtain estimates of tailings quantities at each location, and these were then compared to Atomic Energy Commission estimates of tailings volumes (based on tons of processed ore) and a final estimate of tailings volumes was obtained. A summary of the quantities of tailings and radioactivity in the seven tailings piles is given in Table 3. Since the 1963 survey, two more mills have discontinued operations, and the tenth mill at Monticello, Utah, was not sampled since the tailings had been covered in an

---

*Also operated as a processing mill.

Table 3. TAILINGS PILE MATERIAL AND ISOTOPIC QUANTITIES
AT SEVEN CLOSED URANIUM MILLS - 1963

	Tons Material	Radium-226		Thorium-230		Uranium		Lead-210	
		pg/g	grams	pc/g	curies	%	tons	pc/g	curies
Rifle (old mill)	370,000	557	187	399	134	0.027	100	146	49
Naturita	220,000	594	118	474	95	0.035	77	39	8
Naturita (upgrading)	70,000	147	9	174	11	0.047	33	99	6
Slick Rock	360,000	140	45	42	14	0.007	25	50	16
Durango (small pile)	380,000	633	218	347	120	0.031	118	46	16
Durango (large pile)	1,300,000	992	1,170	918	1,084	0.034	443	213	251
Green River	86,000	143	11	53	4	0.013	11	19	1
Gunnison	540,000	407	199	202	99	0.007	54	61	30
Hite	26,000	555	13	199	5	0.024	6	191	5
	3,352,000		1,970		1,566		867		382

extensive tailings pile control program.

Not all of the mills listed have tailings piles as susceptible to direct erosion to a stream as some of those mentioned earlier, but several are subject to considerable wind erosion to nearby communities and farmland.

The Appendix of this report presents a brief description along with aerial and surface photographs of tailings pile characteristics at a number of uranium mills in the Basin. Suggested control measures for each location are also given, with the estimated costs for control measures at eight closed mills presented in the next section of this report.

Photographs of the Monument Valley and Tuba City mills are not included in the Appendix. Both mills are located some distance from large population concentrations and far from flowing streams, although there has been concern expressed over the possibility of eventual erosion of the Tuba City tailings toward Moenkopi Wash. A number of Indian families live in the vicinity of the mill and consideration should be given to stabilizing this pile in some manner to minimize or prohibit long-term water and/or wind erosion to surrounding areas. Consideration should also be given to the possibility of any spreading of the Monument Valley tailings pile that might affect any Indian families in the area or that could eventually lead to spread of the tailings through some dry washes in Cane Valley.

At the request of the Atomic Energy Commission, the small pile at Hite, Utah, was investigated in November 1963 to determine if the pile would have an effect on reservoir radiation levels when the rising waters of Lake Powell ultimately covered the pile. Shortly thereafter, the Vanadium Corporation of America removed quantities of "high grade" tailings containing the higher isotopic concentrations from the site. In most reservoirs on the Colorado River, silt deposition is recognized as a normal factor. From an analysis of silt loadings, it was expected that several feet of silt would cover the inundated pile within a short time. This factor, the isolated location of the pile, the small quantity of radium-226 (13 grams) contained therein, and the large dilution factor represented by Lake Powell was the basis for the action taken to allow the waters of Lake Powell to cover this small pile.

In October 1965, after the pile had been covered with water and sediment, a series of water and bottom sediment samples were collected from Lake Powell in the immediate vicinity of the pile and at intervals to four miles upstream and downstream from the pile. Sampling indicated the pile was well covered with sediment, and radiochemical analyses of both water and sediment samples indicated no significant variation in radioactivity levels between samples collected upstream and downstream from the pile, as well as over the pile.

ESTIMATED COSTS OF CONTROL METHODS

As pointed out earlier in this report, the Project recommends that interim control of tailings be instituted without undue delay. To this end, costs of various control methods at eight closed mills have been estimated and are given on pages 32 through 35. These estimated costs represent estimates for construction of the various control methods which are considered, and do not include engineering costs which might be required before construction could be instituted. The actual application of these control methods is discussed in more detail in the Appendix.

Earth diking and concrete cribbing wall was evaluated for pile containment, but concrete cribbing proved to be prohibitively expensive in comparison to earth dikes. Riprap was utilized in several estimates for protection of dikes from river erosion.

Diking has been suggested at a number of mill locations. This method might be avoided or replaced by leveling the pile to a gentle overall slope and covering with earth. This would entail moving considerably more tailings material and good plant cover for erosion control would be a must, but the control should be equally adequate and possibly longer lasting. Costs would probably be about the same or less than those estimated for diking.

Two petroleum products which can be applied by spraying, "Peneprime" and "Unilite"*, were investigated for the purpose of covering piles to reduce wind erosion. The costs of these two products, given later, should represent the general cost range of this type of product. The "Peneprime" exhibits a penetrating effect in contrast to the crust-like "Unilite", and use of either of these products would probably preclude vehicular or foot traffic on the treated pile.

* "Peneprime" is a product of the Empire Petroleum Company of Denver, Colorado, and "Unilite" is a product of Allied Crossroads Nuclear Corporation of New York, New York.

Earth covering at a depth of two feet (considered sufficient to support plant growth) was used in obtaining control cost estimates for this report and is considered to be much more permanent and desirable than petroleum product coverings. It also has the added advantages of making the pile potentially economically useful, such as for industrial property. For a 24-inch depth, up to $0.52 per cubic yard could be paid for dirt before surpassing the unit cost of petroleum product coverings. When covering with earth to support vegetation, use of topsoil on the upper several inches would probably be necessary, along with applications of fertilizer before seeding.

Although a 24-inch earth cover is probably more than would be required to support vegetation, this thickness is used in this report to insure sufficient root depth to allow plants to prosper and to provide cover cost estimates that would not be too low. If satisfactory plant cover were attainable on less cover thickness, and if thinner cover would satisfactorily resist water erosion, costs would be proportionately less than those estimated herein. Vegetation growing directly on tailings piles in the Basin is conspicously absent, although small isolated tumble weed plants have been observed growing on the Maybell, Colorado, pile. The apparent lack of plant food in the tailings pile material and the low average rainfall throughout the Basin makes it appear that establishing vegetation directly on Basin piles is unlikely.

Several nickel and gold mining and milling companies in Ontario, Canada, have had excellent success in growing grassy vegetation directly on their tailings piles with no earth covering, but again it appears doubtful that this could be accomplished on Colorado River Basin uranium mill tailings piles for the following reason. The most critical factor in maintaining growth on the Ontario piles has been the pH of the tailings. On tailings piles with a pH of approximately 5.5 or less, the probable condition of most Basin piles, periodic applications (every 3 or 4 years) of agricultural lime is required to bring the pH up to 6.5 or 7.0. Since such periodic maintenance may not be practical once Basin mill owners leave the mill site, the use of an earth covering to support plant growth on the low pH tailings piles is suggested in this report. Once plant growth is established on the covered tailings piles, it seems reasonable to expect that it will maintain itself if plants native to the area are used.

Plant growth is established on the Ontario tailings by machine seeding of a grass seed mixture consisting of 50 percent Canada Blue grass and 50 percent mixed Timothy, Red Top, Fescue, Crested Wheat and Kentucky Blue grass. The seeding is preceeded by a fertilizer application, and then yearly application thereafter.

One gold mill in Ontario has achieved an excellent grass cover on its tailings pile with no yearly fertilizing or lime application. The mill began planting New Zealand Fescue, a dry-land variety of grass, in 1946 and this has needed no maintenance since. The pH of these tailings ranges from about 6.0 to 8.0, thereby dispensing with the need for pH control through application of lime. Seeding costs at the Ontario locations have ranged from $250 to $300 per acre.

The Colorado River Basin Project has available an unpublished detailed report on the Ontario tailings control measures, and several other published papers on the subject are available (16)(17).

Several uranium milling companies have given thought to the possibility of placing snow fence on pile surfaces to either reduce wind erosion of tailings material or to catch sand that is already blowing around the countryside and thereby form a type of self-made covering for the pile. This latter method has been suggested for desert areas where blowing sand can be a prevalent condition. Some attempt at using snow fence for wind erosion control has been tried at the Gunnison, Colorado, mill and as noted on Appendix pages A-9 and A-10 results have been dubious in terms of restricting erosion. Questions have been raised regarding the self-covering of desert tailings piles as to whether as much or more tailings material would be blown off the piles as there was sand blown onto the pile. Union Carbide Corporation is conducting some experimental work on the Maybell, Colorado, pile utilizing various snow fence configurations on the pile surface to determine if efficient wind erosion control can be obtained in this manner.

Cost estimates for the various aforementioned control methods for tailings piles have been obtained by using the unit cost figures discussed below. These figures are based on information regarding construction costs obtained from the Colorado State Highway Department, the Bureau of Reclamation, several construction material supply companies, and three construction contractors currently doing work in the Colorado River Basin who are familiar with uranium mill tailings piles. Construction costs were also discussed with several representatives of the uranium milling industry. The costs discussed below represent estimated construction costs that might be expected if the work was conducted by a private contractor.

Earth Covering

The construction contractors, in particular, were quick to point out that they needed to know the exact engineering requirements at each individual pile, such as dirt placement, compaction, specification, dirt hauling distances, and type of dirt (rocky or fine grained), before they could provide specific cost estimates for a pile. For this reason they suggested ranges of costs that would cover the varying situations from pile to pile.

For hauling dirt that contains no significant amount of rock for a distance of generally 500 feet or less, dumping it and spreading it over the pile, $0.35 to $0.40 per cubic yard was generally quoted. On large jobs, such as those undertaken by the Bureau of Reclamation and the Colorado State Highway Department, hauling dirt up to one-half mile can still be accomplished for about $0.40 per cubic yard. If longer haul distances are required, an additional $0.15 to $0.20 per yard mile is normally added to estimate costs. If dirt had to be acquired from an area containing rock that would require breaking up before it could be hauled, costs could go to $1.00 per cubic yard and more, depending on haul distance again.

Using the construction term of "ballpark" estimating for work with so many unidentified parameters, $0.60 to $0.70 per cubic yard was suggested as a conservative cost range for covering tailings piles with dirt. When a specific control measure at a specific mill is decided upon, actual costs can be more or less than this range, according to the parameters described For use in this report, $0.70 per cubic yard was picked as a general unit cost for estimating purposes. It is estimated that costs at most mills in the Basin will be less than $0.70 per cubic yard since reasonably good dirt appears to be available in the vicinity of most existing piles.

Another factor on dirt costs could also enter the picture. If a good source of dirt was not available in the vicinity of the tailings pile, it still might be necessary to purchase the land in order to obtain the dirt, thereby raising the overall cost accordingly. In most cases, mills own land adjacent to the tailings piles and dirt acquisition would not be a problem.

Using $0.70 per cubic yard, square yard costs for various depths of earth cover would be:

$0.23 per square yard for 12-inch depth
$0.35 per square yard for 18-inch depth
$0.47 per square yard for 24-inch depth

Earth Dike Construction

Hauling dirt to the pile for construction of retaining or protective dikes would cost the same as for covering the pile. Generally, $0.06 to $0.10 per cubic yard is then added to the hauling costs for covering costs of compaction. This cost will vary depending on the degree of compaction specified, whether it is to be wet down and rolled by compaction equipment or compacted with normal equipment travel over the dike during construction.

The higher figure of $0.10 per cubic yard is used in this report when estimating the costs of earth dike compaction.

"Peneprime" Covering

$0.35 per square yard

"Unilite" Covering

$0.45 per squard yard

Concrete Cribbing

$5.60 per square foot of wall facing, plus delivery cost from Denver (the nearest supply) of $0.30 per trip mile for a 40,000 pound load. Steel cribbing was not considered due to its tendency to retain water in the pile.

Bulldozing

Average bulldozer rates are about $175 per 8-hour day. Bulldozers could be used for leveling and shaping the piles before covering.

Riprap

Placing rock riprap on dikes to protect them from stream erosion received estimates of $5 to $12 per cubic yard for dumped rock, and about $20 per cubic yard for placed work. Since good rock for riprap may require long haul distances in the Colorado River Basin area, $12 per cubic yard is used for estimating purposes in this report, assuming the use of dumped rather than placed rock.

Using the figures described above, the following cost estimated have been obtained for various tailings pile control measures at eight nonoperating mills in the Basin. No estimates have been prepared for operating mills since their tailings piles are still growing and changing, but the costs presented should be indicative of costs that might be expected at these mills.

Rifle (old mill) - 76,000 square yards

Dike and Earth Covering (recommended control method)

Shaping and leveling the pile, 1,740 feet of dike and 24-inch earth cover: $40,000

Dike and "Peneprime" Covering

Shaping and leveling the pile, 1,740 feet of dike and "Peneprime" cover: $30,000

Dike and No Cover

Shaping and leveling the pile, 1,740 feet of dike: $ 6,000

Naturita - 73,000 square yards

Dike and Earth Covering (recommended control method)

Shaping and leveling the pile, 2,800 feet of dike with 1,200 feet of riprap and 24-inch earth cover: $44,000

Dike and "Peneprime" Covering

Shaping and leveling the pile, 2,800 feet of dike with 1,200 feet of riprap and "Peneprime" cover: $35,000

Naturita (continued)	
Dike with No Covering	
Shaping and leveling the pile, 2,800 feet of dike with 1,200 feet of riprap:	$11,000
Concrete Cribbing with No Covering	
Shaping and leveling the pile, 21,000 feet of dike and 740 feet of cribbing:	$29,000
Slick Rock - 56,000 square yards	
Dike and Earth Covering (recommended control method)	
Shaping and leveling the pile, 1,700 feet of dike with 900 feet of riprap and 24-inch earth cover:	$42,000
Dike with No Covering	
Shaping and leveling the pile, 1,700 feet of dike with 900 feet of riprap:	$15,000
Gunnison - 156,000 square yards	
Earth Covering (recommended control method)	
24-inch earth cover:	$72,000
"Peneprime" Covering	
156,000 square yards "Peneprime":	$55,000
Green River - 32,000 square yards	
Earth Covering (recommended control method)	
Shaping and leveling the pile, retrieving eroded tailings material and covering with one foot of earth:	$ 9,000

Durango

Even minimum pile control at Durango would require moving more than

500,000 cubic yards of material. At the truck and shovel rate of $0.40 per cubic yard, control costs would begin at $200,000.

If the pile is capable of supporting bulldozers, probably the cheapest means of control would be spreading the pile over the existing mill area, dynamiting the mountainside above the pile, bulldozing the fallen material over the pile, and finally covering with enough topsoil to support plant life.

Moving half the pile (500,000 cubic yards) by bulldozer is estimated to cost about $150,000.

Maybell

No topographic survey has been conducted at this recently closed mill; therefore, no qualitative figures are available to obtain control cost estimates. Suggested minimum control methods of providing runoff intercepting ditches at the pile periphery and improving tailings dike stability by covering the dikes with earth would probably cost about $20,000. There has been considerable wind movement of tailings material noted at this pile, and measures to stabilize the entire pile surface by covering with two feet of earth could cost $100,000 or more.

Mexican Hat

Here again, no quantitative figures on the size of the Mexican Hat tailings pile have been obtained since the mill ceased operating. Minimum control measures of damming some dry washes to prohibit erosion of the pile material into the washes would probably cost about $5,000. Additional control measures of covering the tailings dikes or the entire pile would cost considerably more.

BIBLIOGRAPHY

1. Tsivoglou, E. C., O'Connell, R. L., Waste Guide for the Uranium Milling Industry, Technical Report W62-12, U. S. Dept. of Health, Education, and Welfare, Public Health Service, R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio, 1962.

2. Tsivoglou, E. C., Bartsch, A. F., Rushing, D. E., and Holaday, D.A., Report of Survey of Contamination of Surface Waters by Uranium Recovery Plants, U. S. Dept. of Health, Education, and Welfare, Public Health Service, R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio, 1956.

3. Tsivoglou, E. C., et al., Estimating Human Radiation Exposure on the Animas River, Journal AWWA, 52, 10, 1271, October 1960.

4. Report of the Ad Hoc Committee of the National Committee on Radiation Protection and Measurements, Somatic Radiation Dose for the General Population, Science, Vol. 131, page 482, February 1960.

5. Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and Water for Occupational Exposure, NCRP, National Bureau of Standards, Handbook 69, Washington, D.C., June 1959.

6. Federal Radiation Council, Radiation Protection Guidance for Federal Agencies, Memorandum for the President, May 13, 1960.

7. International Commission on Radiological Protection, ICRP Part 2, Report of Committee II on Permissible Dose for Internal Radiation, Pergamon Press, London, 1959.

8. Atomic Energy Commission Clearing House, Vol. 11, No. 15, Congressional Information Bureau, Inc., April 12, 1965.

9. Holliday, D., Introductory Nuclear Physics, John A. Wiley and Sons, Inc., New York, N.Y. 1950.

10. A Description of Uranium Mines and Mills and Radioactive Wastes, Working Group No. 6, Subcommittee N5.2, ASA Sectional Committee N5, ASA (Draft), May 1962.

11. Shearer, S.D., The Leachability of Radium-226 from Uranium Mill Waste Solids and River Sediments, Ph.D. Dissertation, University of Wisconsin, 1962.

12. Radiological Content of Colorado River Basin Bottom Sediments, August 1960-August 1961, Project Report PR-10, Colorado River Basin Project, U. S. Public Health Service, Region VIII, Denver, Colorado, June 1963.

13. Wruble, D.T., Shearer, S.D., Rushing, D.E., and Sponagle, C.E., Radioactivity in Water and Sediments of the Colorado River Basin, 1950-1963, Radiological Health Data, Vol. V, No. 11, Superintendent of Documents, U. S. Government Printing Office, Washington, D.C., November 1964.

14. American Society of Civil Engineers Manual of Engineering Practice - No. 40, Ground Water Basin Management, 1961.

15. Public Health Service, Drinking Water Standards, Public Health Service Publication No. 956, Revised 1962.

16. Chenik, D., The Promotion of Vegetative Cover on Mine Slimes and Sand Dumps, Journal of South African Institute of Mining and Metallurgy, July 1960.

17. MacKenzie, A. Douglas, Report #1, The Promotion of Vegetation on Tailings Dam Banks, Quebec Department of Technical Economics, 240 Hymus Boulevard, Pointe Claire, Quebec.

APPENDIX

RIFLE (old mill) - Wind erosion carries pile material into the drainage ditch along the railroad embankment to be carried by runoff to the Colorado River.

RIFLE (old mill) - Precipitation runoff from over the pile has broken the tailings dam at the southwest corner of the pile and carries pile material to the Colorado River.

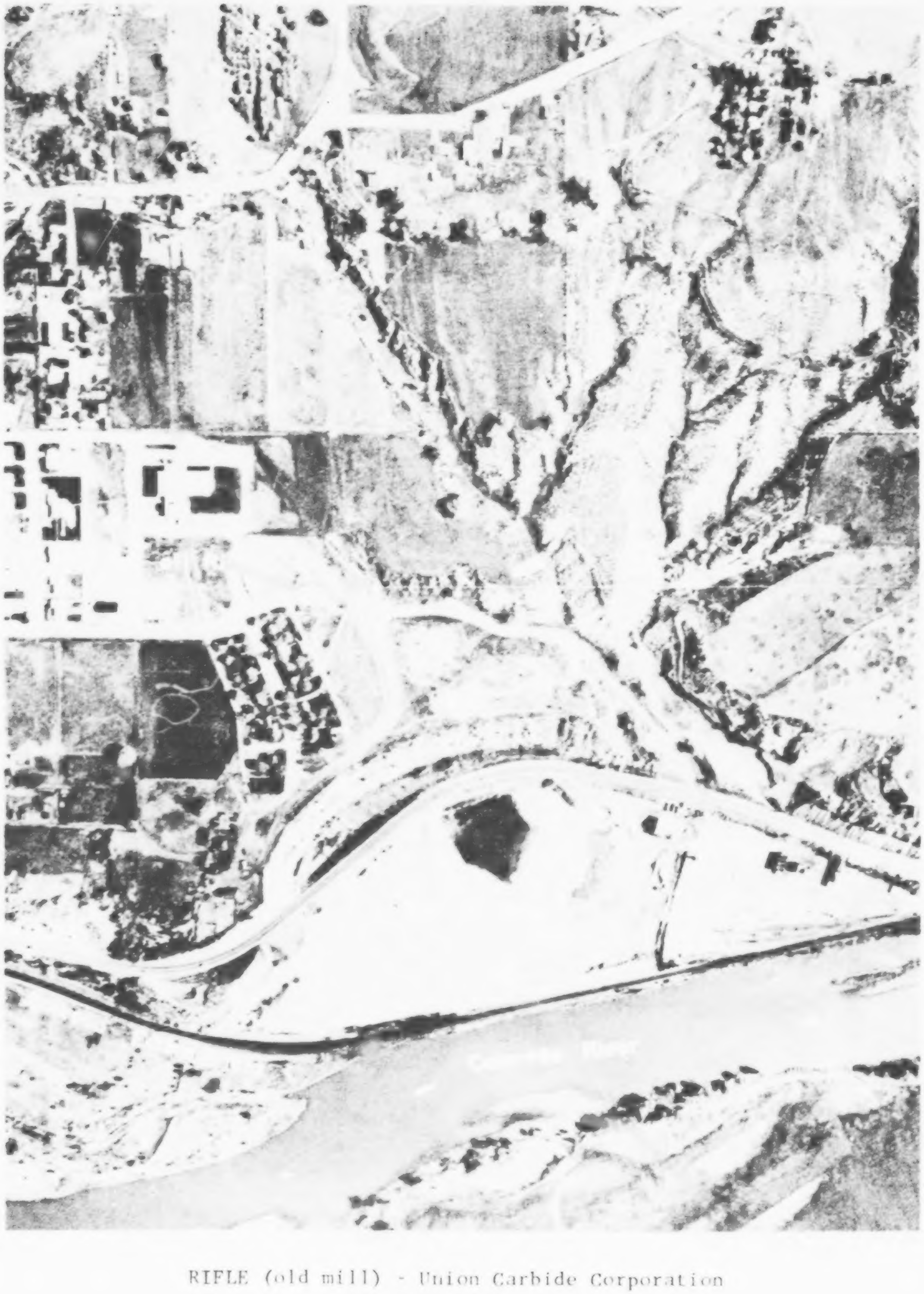
Rifle (old mill) - Nonoperating

Approximately 370,000 tons of tailings material is piled at the old Union Carbide Corporation mill near Rifle, Colorado. The company has been transporting tailings material from the east side of the pile (all aerial photos are oriented with north to the top of the page unless otherwise noted) to the new Rifle mill for reprocessing to recover vanadium values. The pile is separated from the Colorado River by a railroad embankment, but erosion from surface runoff has been observed to carry material from the pile along the embankment and through a culvert to the river.

A pond of water kept at constant level by ground water seepage exists in the pile, which probably means that the bottom of at least a portion of the pile is subject to ground water leaching. There is no substantial domestic ground water use in the immediate area of the pile.

The community of Rifle lies a short distance to the northwest, but probably does not receive much material from the tailings by wind carriage

Suggested control measures include earth diking along the railroad embankment to control both water runoff and wind erosion and then covering the pile with earth for plant growth. Although the area may not be conveniently located for such use as a grazing area, use as a roadside park or an industrial area might be applicable.



RIFLE (old mill) - Union Carbide Corporation

Approximate Scale - one inch equals 500 feet

NATURITA - Pile proximity to the San Miguel River at low flow. Higher flows reach to and onto the pile.

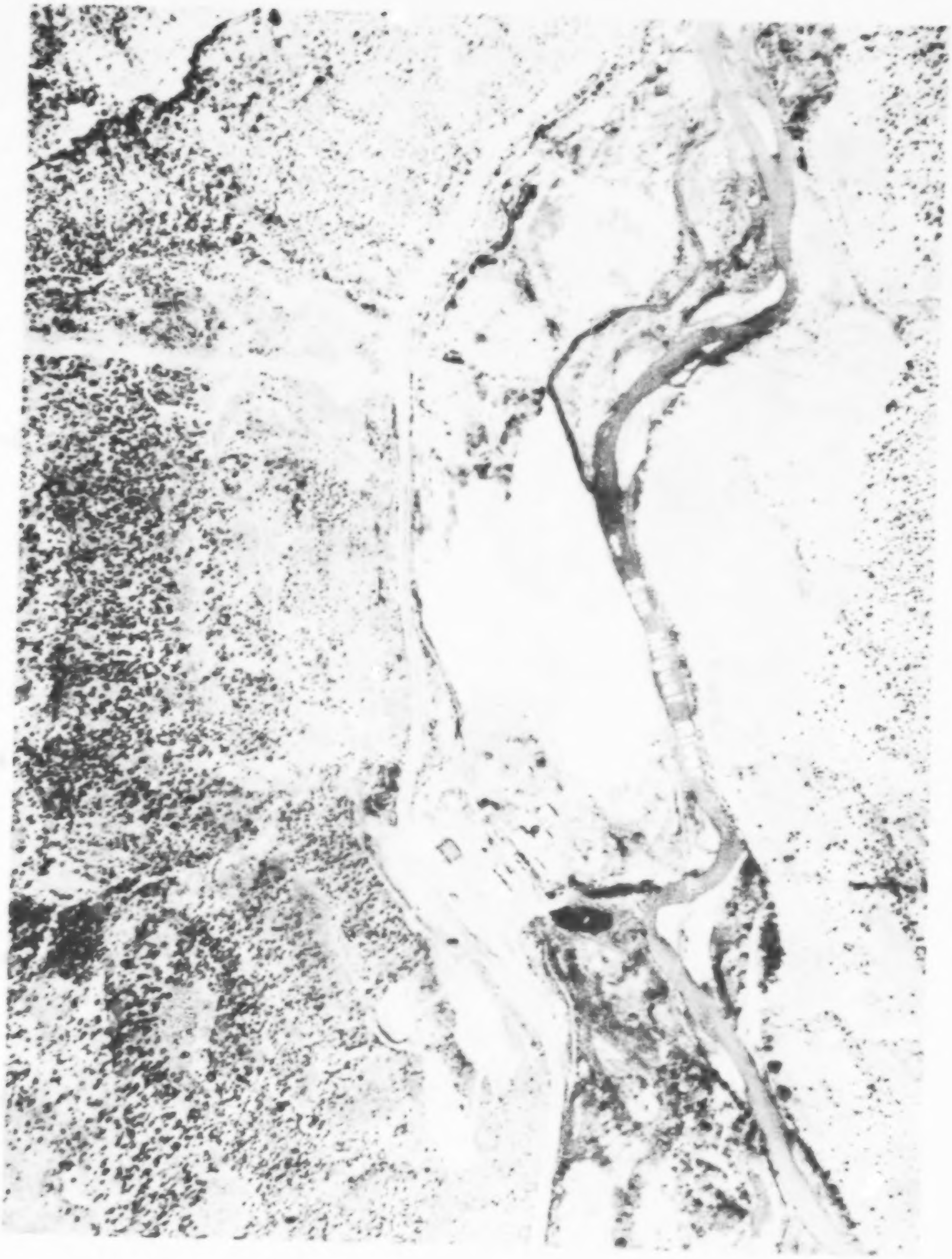
NATURITA - Pile proximity to the dry wash draining runoff from the surrounding area to the San Miguel River.

Naturita - Nonoperating

Approximately 290,000 tons of tailings material are piled on the west bank of the San Miguel River near Naturita, Colorado. This pile is owned by the Vanadium Corporation of America.

The tailings rest on a low flood plain and extend to the river's edge. Wind carriage continually moves the material toward the river, and high river flows usually encroach directly onto the pile. Additionally, a draw which drains runoff from an area southwest of the pile runs along the west and northwest edge of the pile, where runoff picks up tailings pile material before it reaches the river. No significant wind carriage to a community is apparent here, although there are several private residences a short distance upstream from the pile.

Suggested control measures include construction of an earth dike or a retaining wall along the river and along the draw drainage to prevent direct erosion during rains and high flows, and covering the pile to prevent wind carriage over the diking. Riprap along the dike would be needed to prevent erosion of the dike during high river flows.



NATURITA - Vanadium Corporation of America

Approximate Scale - one inch equals 500 feet

SLICK ROCK - Pile proximity to the Dolores River at low flow. Tailings material extends to the water's edge and higher flows cut into the pile.

SLICK ROCK - Surface runoff has eroded a portion of the pile (center right) and carried material across the pile to the Dolores River just to the left of this photograph.

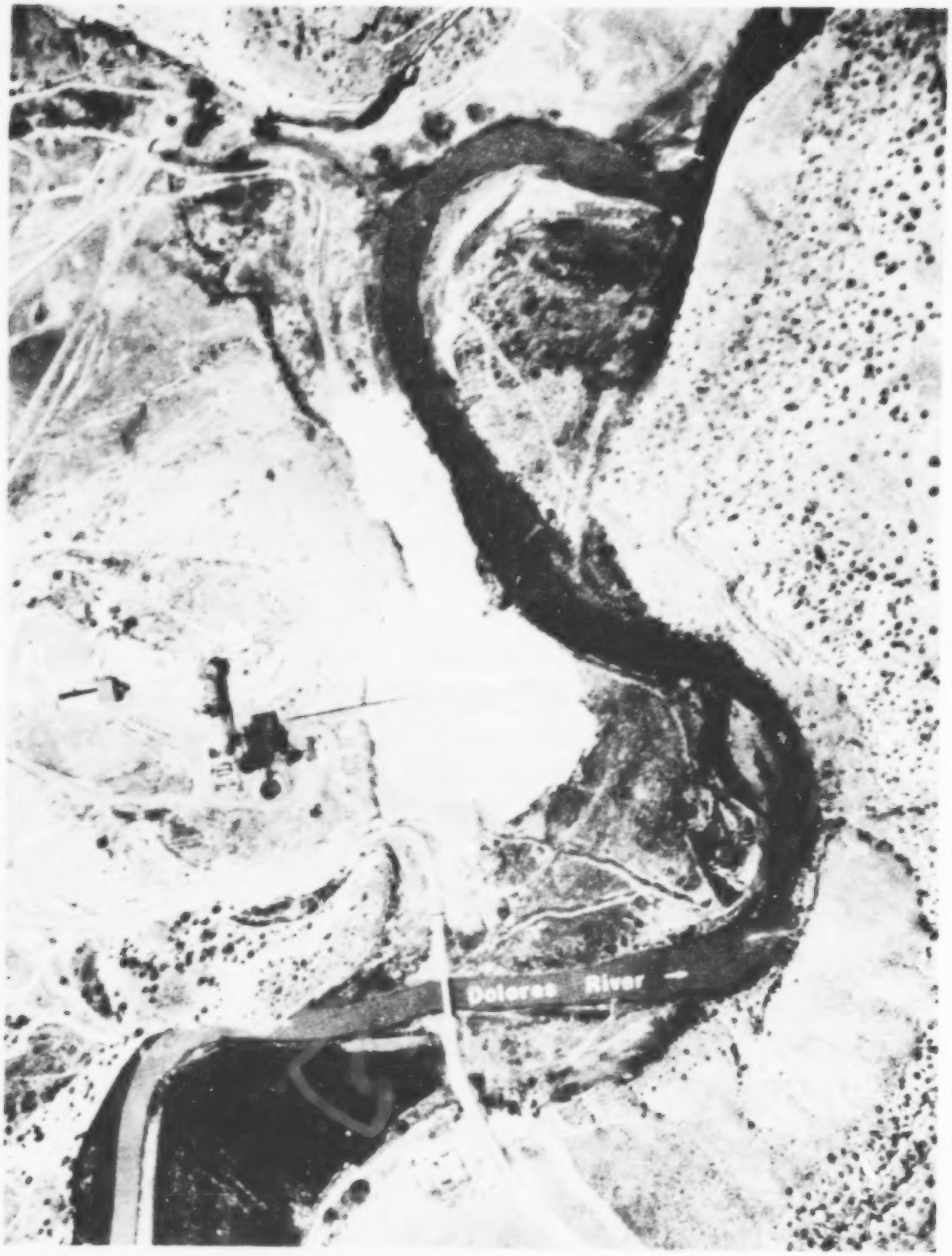
Slick Rock - Nonoperating

Approximately 360,000 tons of tailings are in this pile which lies on a flood plain of the Dolores River at Slick Rock, Colorado. The pile is owned by the Union Carbide Corporation.

Similar to the Naturita tailings, this pile extends to the stream edge and is subject to direct stream erosion at high flows, erosion from pile runoff, and wind carriage to the stream.

Except for a small trailer community of miners and mill maintenance personnel living a short distance west of the pile, there are no communities within a number of miles of this location.

Suggested control measures include diking along the river, riprap to protect the dike during high flows, and at least minimal cover over the tailings to prevent long term wind erosion over the dike. Some diversion ditching along the west side of the pile might also be desirable.


Dolores River

SLICK ROCK - Union Carbide Corporation

Approximate Scale - one inch equals 500 feet

MAYBELL - Tailings material dune along the eastern edge of the pile.

MAYBELL - Wind erosion of tailings material on the southern edge of the pile.

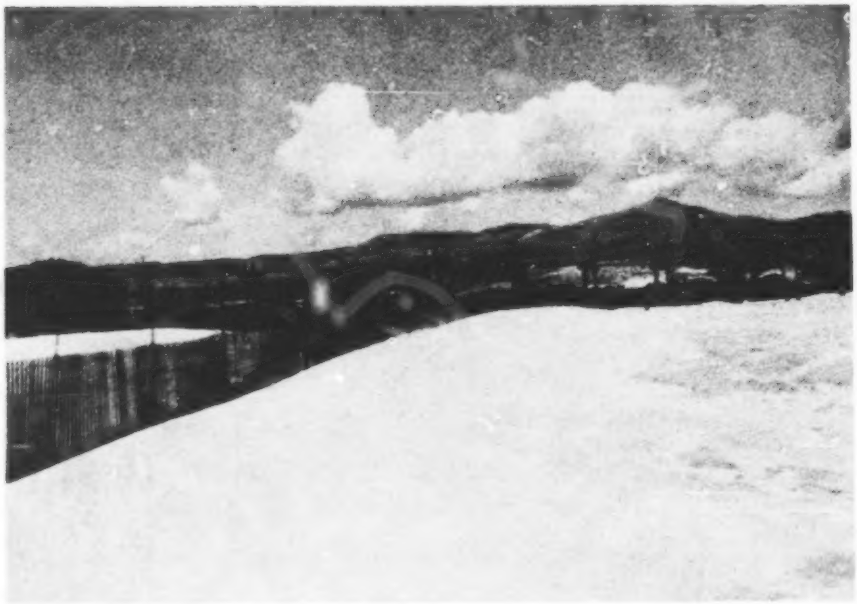
Maybell - Nonoperating

This Union Carbide Corporation 2.5 million ton tailings pile is located about 8 miles from the nearest community, Maybell, Colorado. The pile is well diked to prevent runoff erosion of tailings into Johnson Wash and later into Lay Creek. Due to its remoteness, air carriage of tailings to a community is not likely to be a problem, although a considerable amount of tailings has been moved by wind erosion since the mill closed in November 1964.

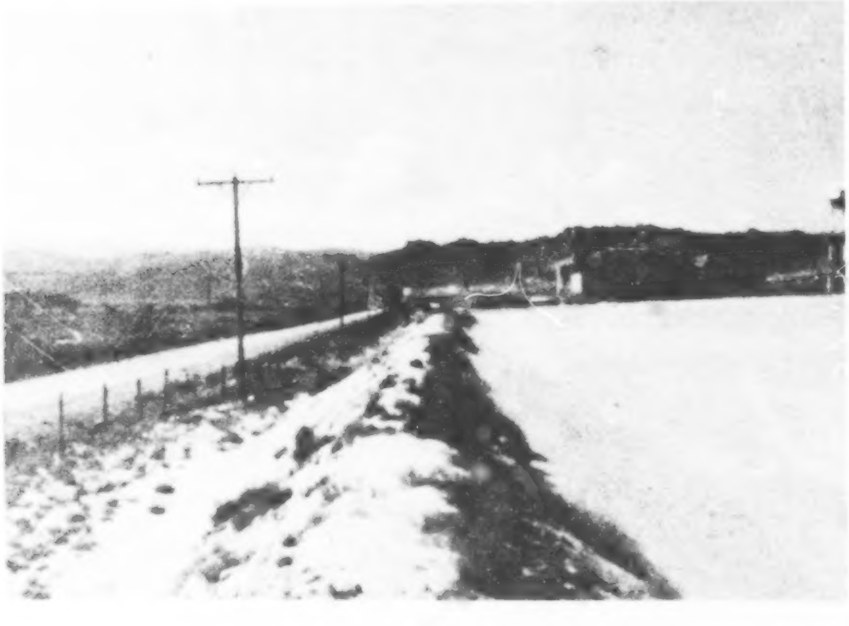
Over a long period of time, some pile erosion from surrounding area runoff may tend to occur. Suggested control measures here would be to provide drainage ditches along pile boundaries to intercept runoff and prevent this flow from traveling over the pile to carry tailings material into Johnson Wash. Since the dikes are constructed of tailings material, additional control might be obtained by reinforcing the tailings dikes with earth to help reduce dike erosion, particularly from wind erosion, over a long term period.

MAYBELL - Union Carbide Corporation

Approximate Scale - one inch equals 1000 feet



GUNNISON - Snowfence on the surface of the pile has collected "drifts" of tailings material.



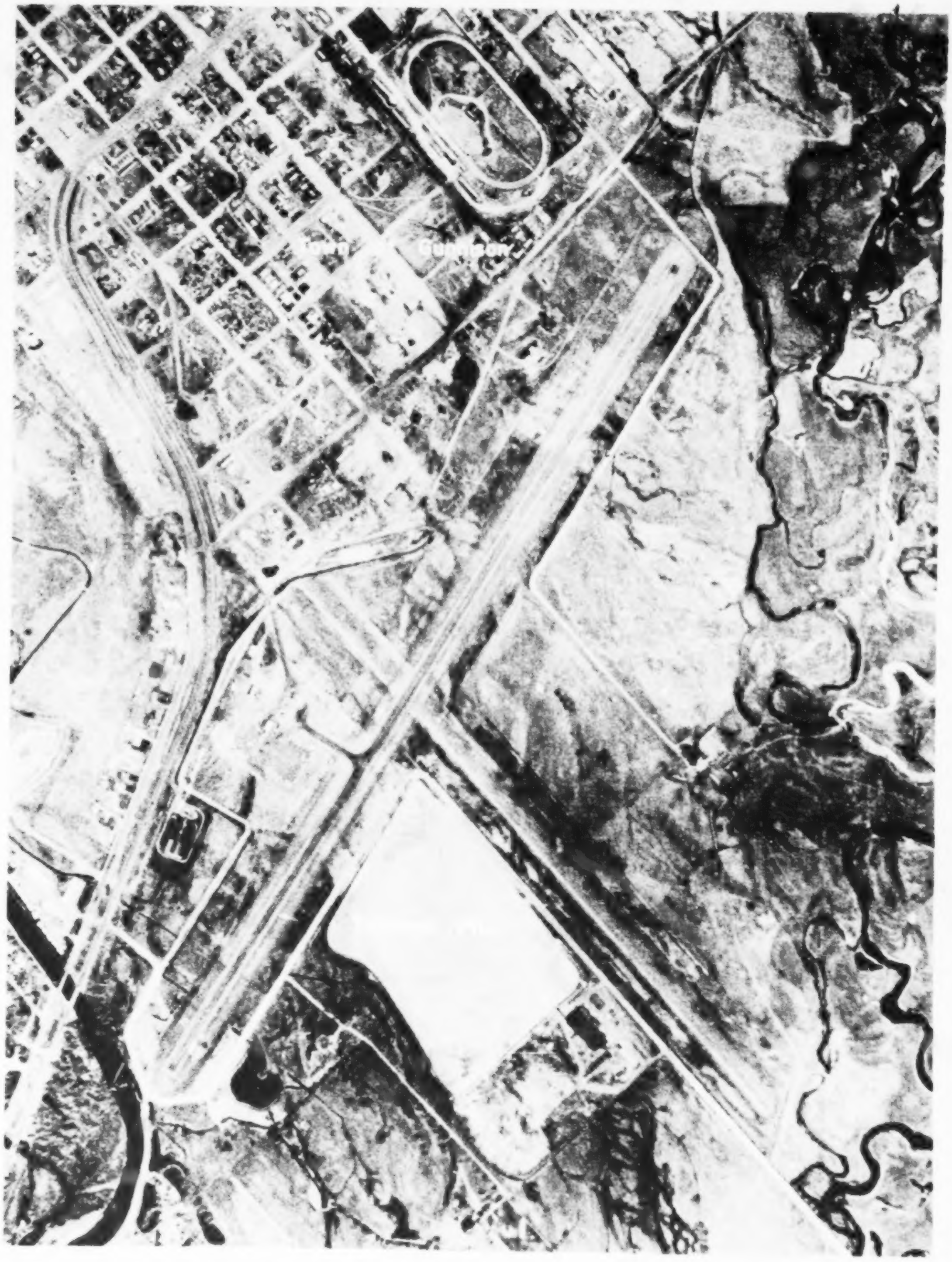
GUNNISON - Wind erosion has carried pile material over the earth dikes in the direction of the town of Gunnison.

Gunnison - Nonoperating

This pile contains about 540,000 tons of tailings and is located just southwest of Gunnison, Colorado. The pile is currently owned by Kerr-McGee Oil Industries.

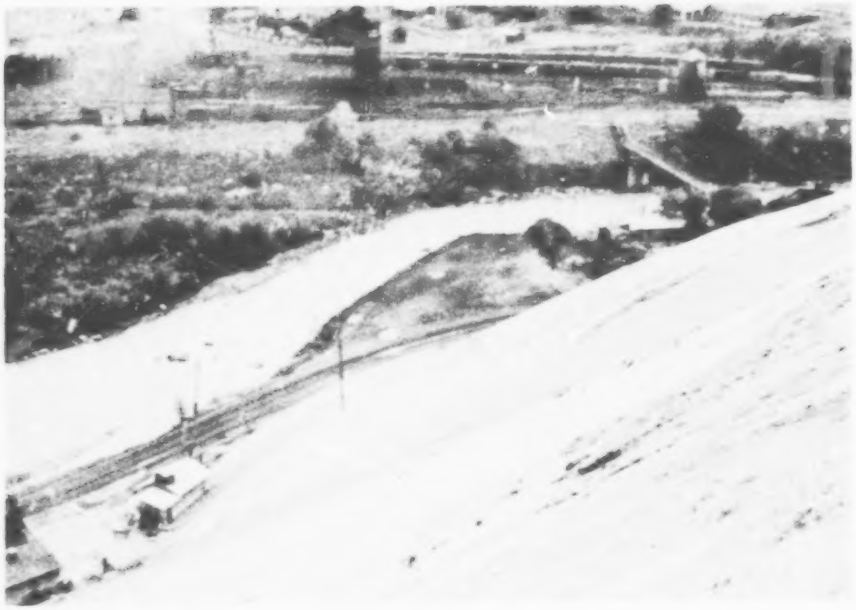
Water erosion of this tialings pile has been controlled by a well constructed earth dike. Wind carriage of this material occurs toward the city, as is evident in the photographs by the tailings covered dikes and areas to the northeast and the drifting tailings material north of the snow fences placed on the pile in efforts to reduce wind carriage. Much of the pile surface has been literally swept clean of this sand-like material, leaving a hardened crust of finer cementitious material.

Earth covering is suggested for wind erosion control. Since large quantities of earth for covering are not readily available in the immediate area, perhaps a covering of only 6 or 8 inches would be sufficient to prevent wind erosion, although this might not support plant life. Application of a petroleum stabilizer to the surface might provide a satisfactory alternative.

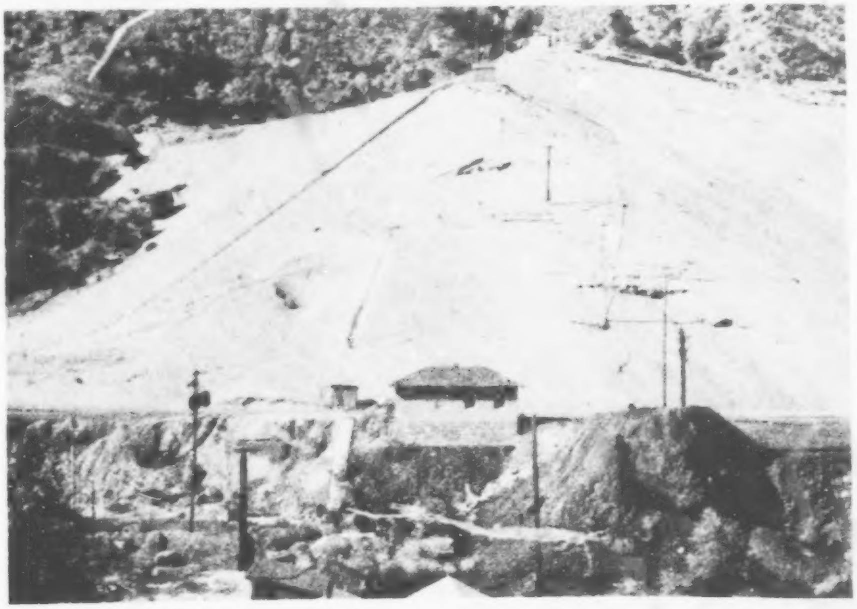


GUNNISON - Kerr-McGee Oil Industries

Approximate Scale - one inch equals 1000 feet



DURANGO - View from the top of the large pile, showing pile proximity to the Animas River.



DURANGO - A small structural failure slide occurred in 1964 (left center) and moved down over the mill road (left of the building). The hole left by the slide has been partially refilled by wind carried tailings material in this photograph, taken a year later.

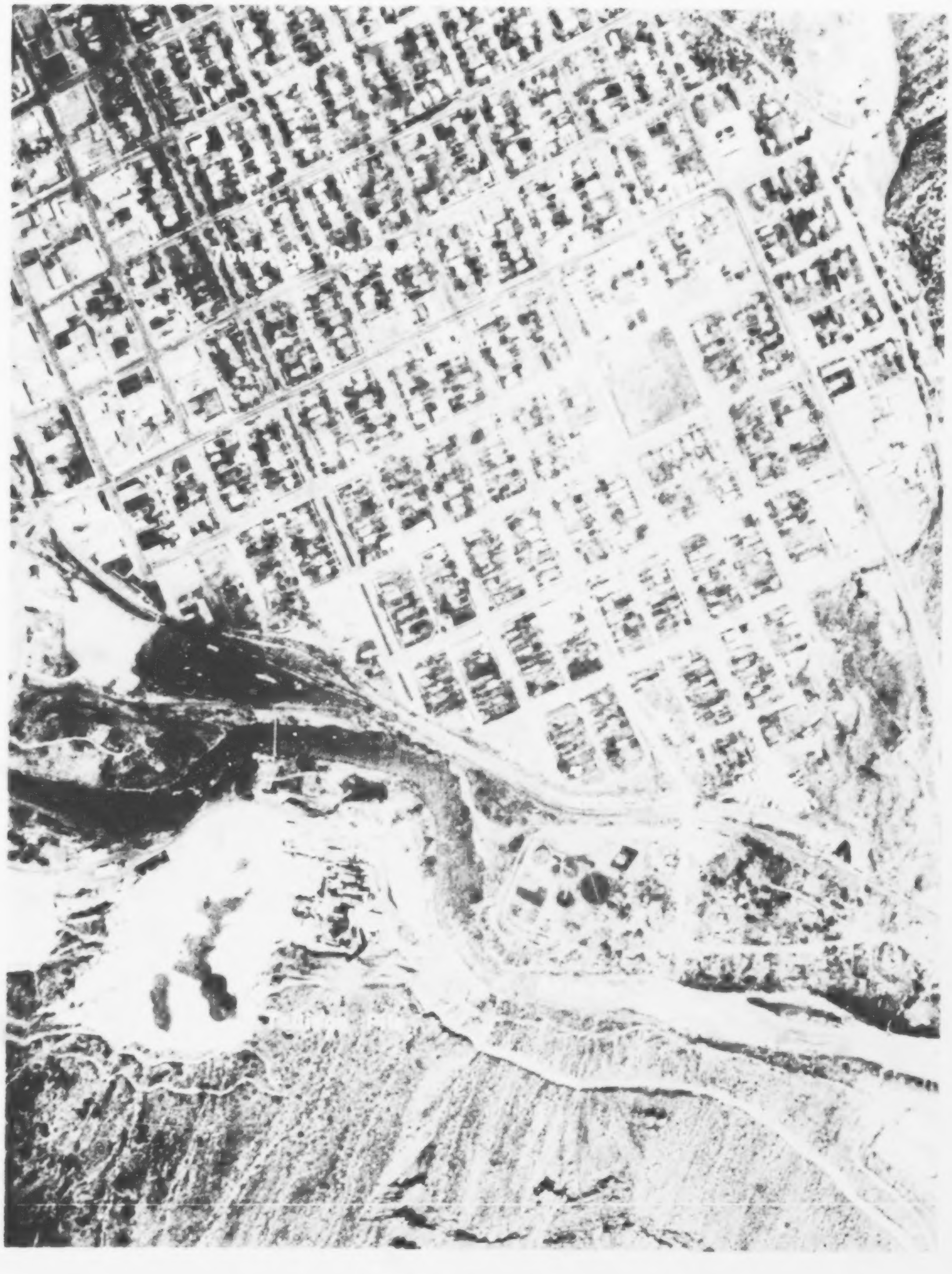
Durango - Nonoperating

There are two separate piles located at the Vanadium Corporation of America mill site at Durango, Colorado. The larger accumulation of approximately 1.3 million tons is piled on a shelf between a steep-sided mountain and the Animas River. The pile is approximately 230 feet high and its sides are at a steep angle of repose, with the toe approximately 20 or 30 feet from the bank of the river at its nearest point. Since at least one small structural failure of the pile has been observed resulting in a small slide (which did not reach the river) the possibility of a large slide into the river cannot be ignored, particularly if precipitation wetted the pile sufficiently to produce further instability. The interior of the pile has been reported to be saturated with moisture.

Another significant factor of environmental contamination is wind carriage to adjacent residential areas of Durango. Efforts have been made to control this erosion by wetting the pile with sprinklers, but as can be seen by the dark area on the pile in the accompanying aerial photograph, the wetted area is limited and thereby rather ineffective.

The second pile (just shown at the left edge of the aerial photo), containing about 380,000 tons of material, is located further away from the river, but is still subject to wind erosion and some water runoff erosion.

Any control measures here will be much more expensive than at other locations in the Basin, but this is offset by the potential for considerable contamination of both the community and the river. The pile could be leveled somewhat by spreading it around the mill property and covering, or leveling, and transporting some portion about a half mile downstream to be covered in the old raffinate liquor evaporation ponds. Under any circumstances, the pile would have to be leveled to a more stable position before covering is attempted to insure no structural failure.



DURANGO - Vanadium Corporation of America

Approximate Scale - one inch equals 500 feet

MEXICAN HAT - Movement of tailings material down a dry wash toward the San Juan River.

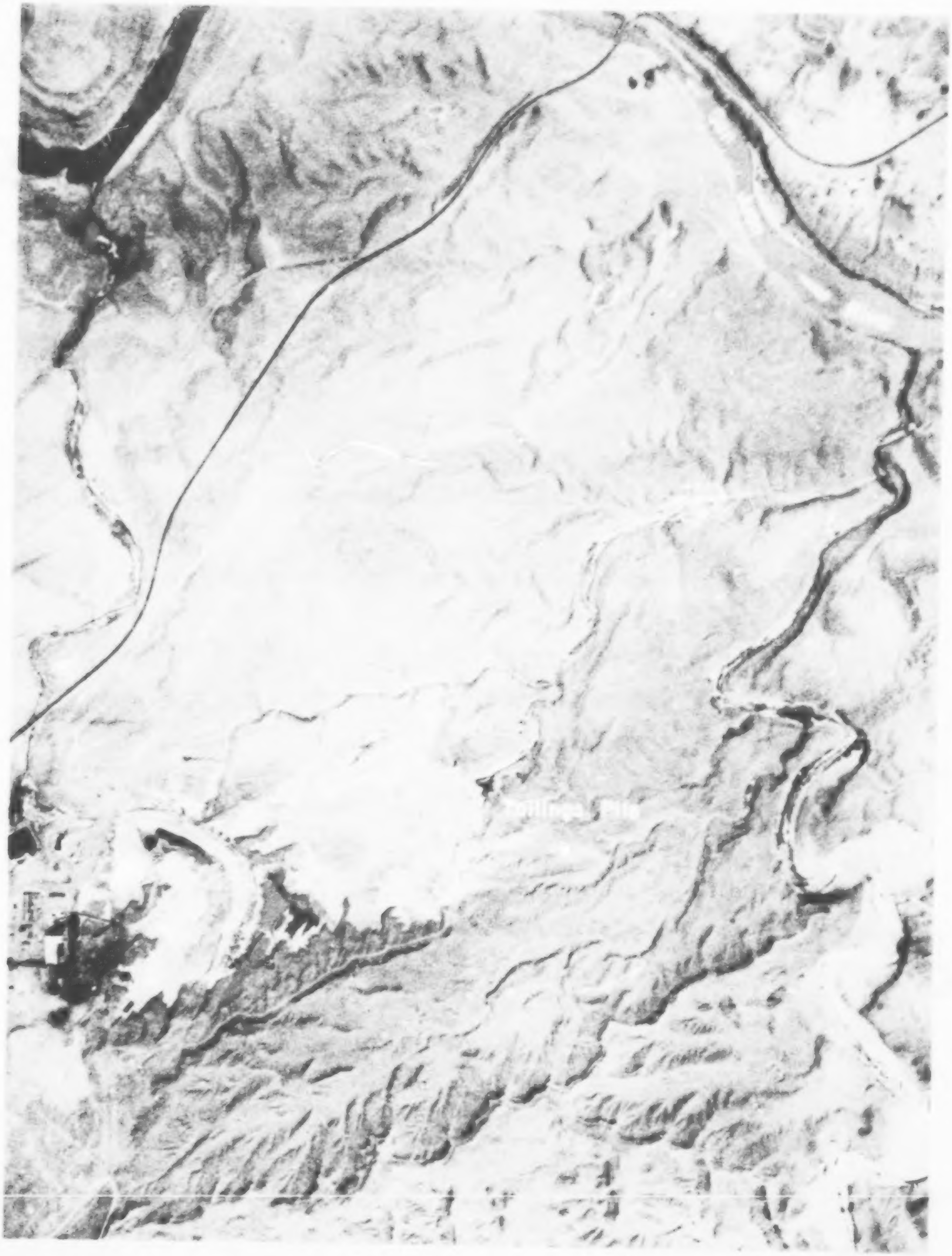
MEXICAN HAT - Wind carried tailings material to the north of the pile.

Mexican Hat - Nonoperating

This mill was operated by AZ Minerals and is located near Mexican Hat, Utah. More than two million tons of tailings are estimated to comprise the tailings pile.

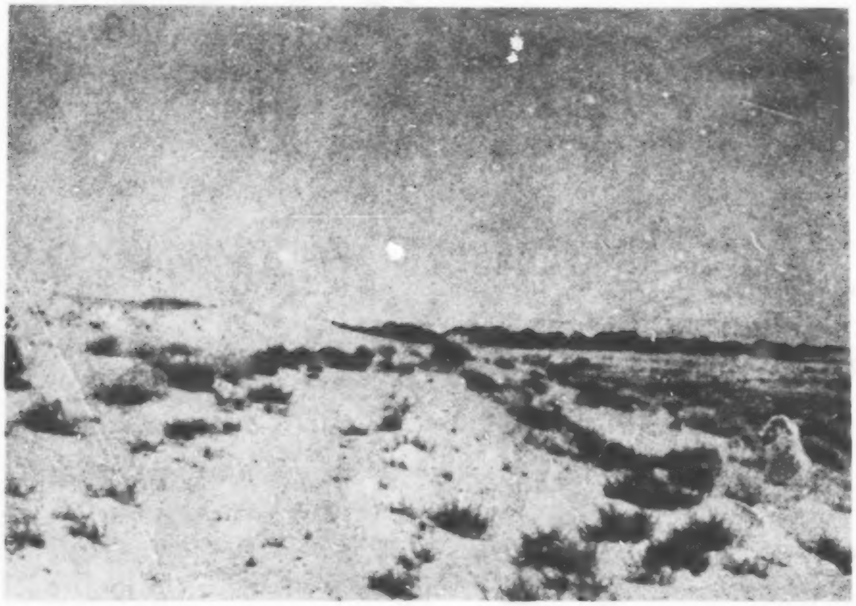
Some transport of tailings pile material by water erosion via washes to the San Juan River is evident, while wind erosion appears of little consequence due to its remote location. A number of mill personnel still live to the south of the pile area and about one mile to the north at Mexican Hat. At this time wind carriage of tailings material toward these residences does not appear to be significant. However, as this pile dries, this factor may assume more importance.

Suggested control measures would be eliminating water erosion by damming the upper ends of the washes near the tailings pile and diverting runoff water to prevent transport of tailings. Adequate containment might also be obtained by covering the pile slopes with a sufficient amount of earth to protect them from erosion to the washes.


Tailings Pile

MEXICAN HAT - AZ Minerals

Approximate Scale - one inch equals 1000 feet



GREEN RIVER - Wind carriage of tailings material from the pile (far left) has carried material over the dike (left) and into Brown's Wash (right).

GREEN RIVER - View from Brown's Wash showing wind carriage over the dike (center).

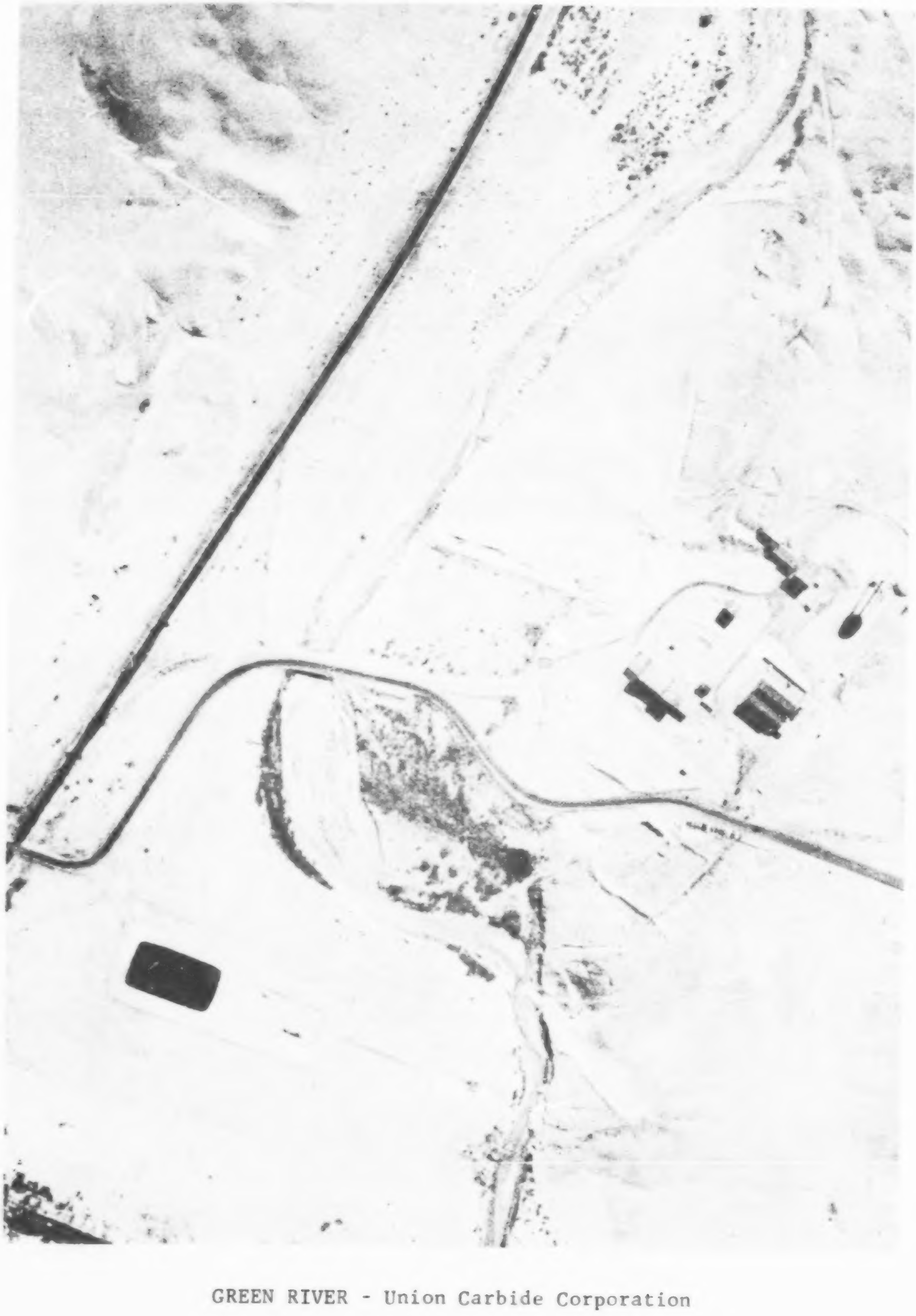
Green River - Nonoperating

This is a small pile of about 86,000 tons near Green River, Utah, owned by the Union Carbide Corporation.

A dike has been constructed to keep this material from entering Brown's Wash (subject to flash flood) which in turn enters the Green River within a few thousand feet. The ability of wind to carry tailings material has been dramatically demonstrated at this location, where wind erosion has carried the tailings over the dike to where the dike is now completely covered with tailings which now lie in the bed of Brown's Wash.

The small community of Green River, Utah lies about 1 mile to the northwest of the pile, but wind carriage in this direction appears minimal.

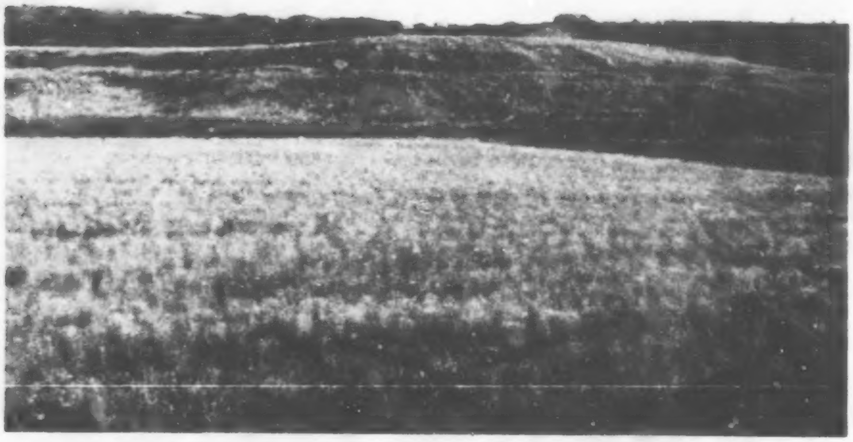
Suggested control measures include leveling the pile within the existing dike, returning the drifted material to within the dike boundaries, and bulldozing about a foot of earth from the nearby low hills over the pile. Vegetation would not grow due to the extreme desert conditions at this location, but earth covering alone should be adequate to prevent blowing. Some additional riprap on the dike along Brown's Wash might also be desirable.



GREEN RIVER - Union Carbide Corporation

Approximate Scale - one inch equals 360 feet

MONTICELLO - Riprap along South Creek to prevent erosion of tailings pile cover.

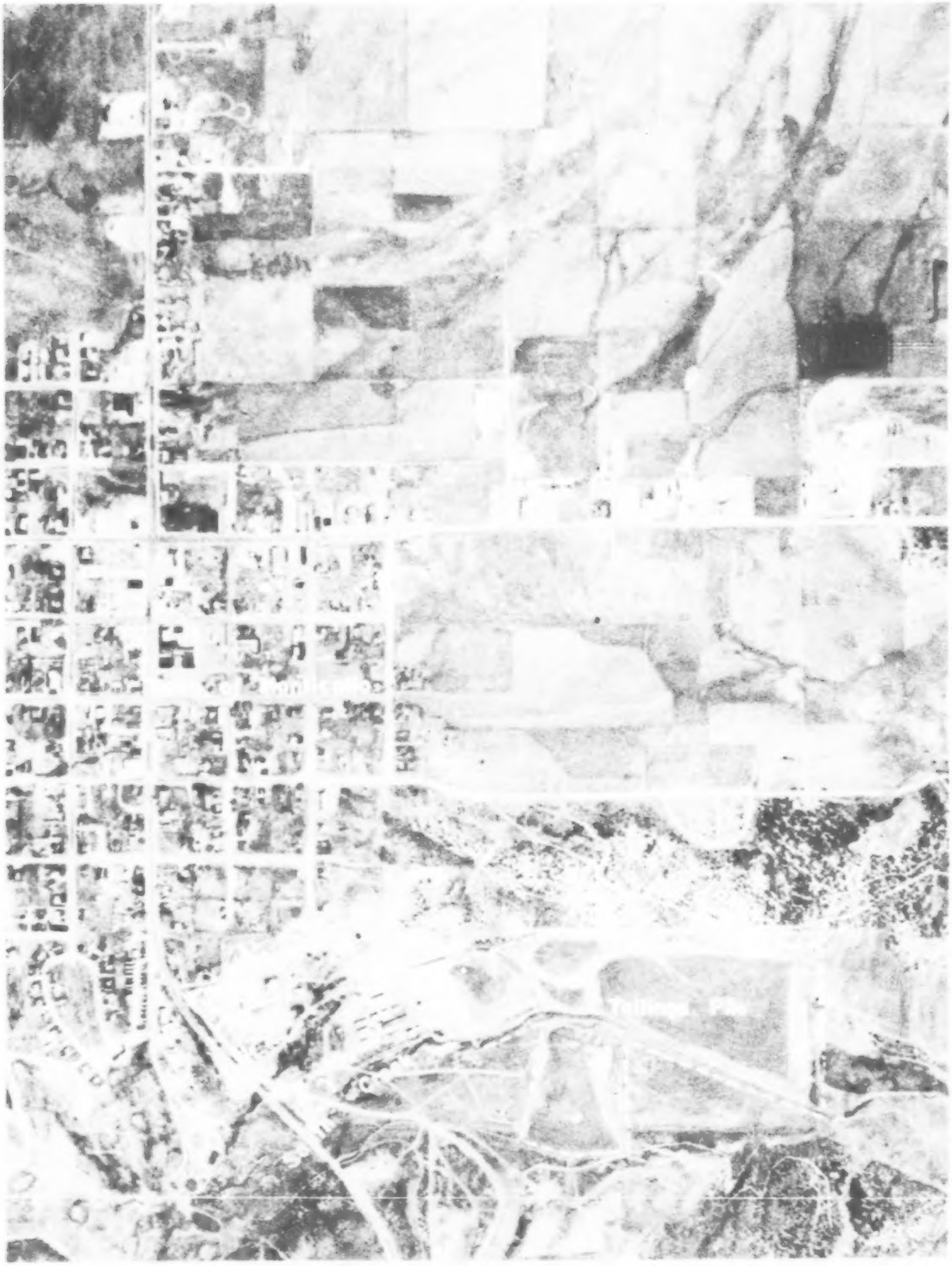


MONTICELLO - Vegetation on top of a covered pile in the foreground and on a pile slope in the background.

Monticello - Nonoperating

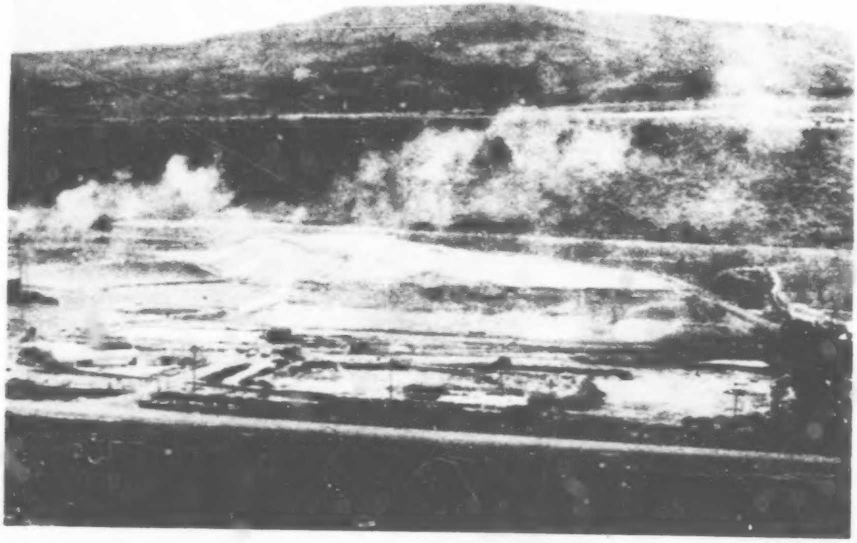
This is a large tailings pile at Monticello, Utah. In 1961, the Atomic Energy Commission undertook an extensive tailings control program of diking, draining, covering, and planting of the exposed tailings piles. The result is an excellent example of the degree of control that can be accomplished.

In the control program, tailings material was removed from the banks of South Creek which runs through the mill property, the tailings piles leveled and sloped, covered with earth and topsoil, fertilized and planted with plant cover native to the area. Additionally, the South Creek banks were riprapped to prevent erosion, small retaining dikes were built to collect pile runoff so slopes would not be eroded, and diversion ditches were constructed on the pile perimeters to prevent excessive runoff over the piles from the surrounding area.


Tailings Pile

MONTICELLO - U. S. Atomic Energy Commission

Approximate Scale - one inch equals 1000 feet



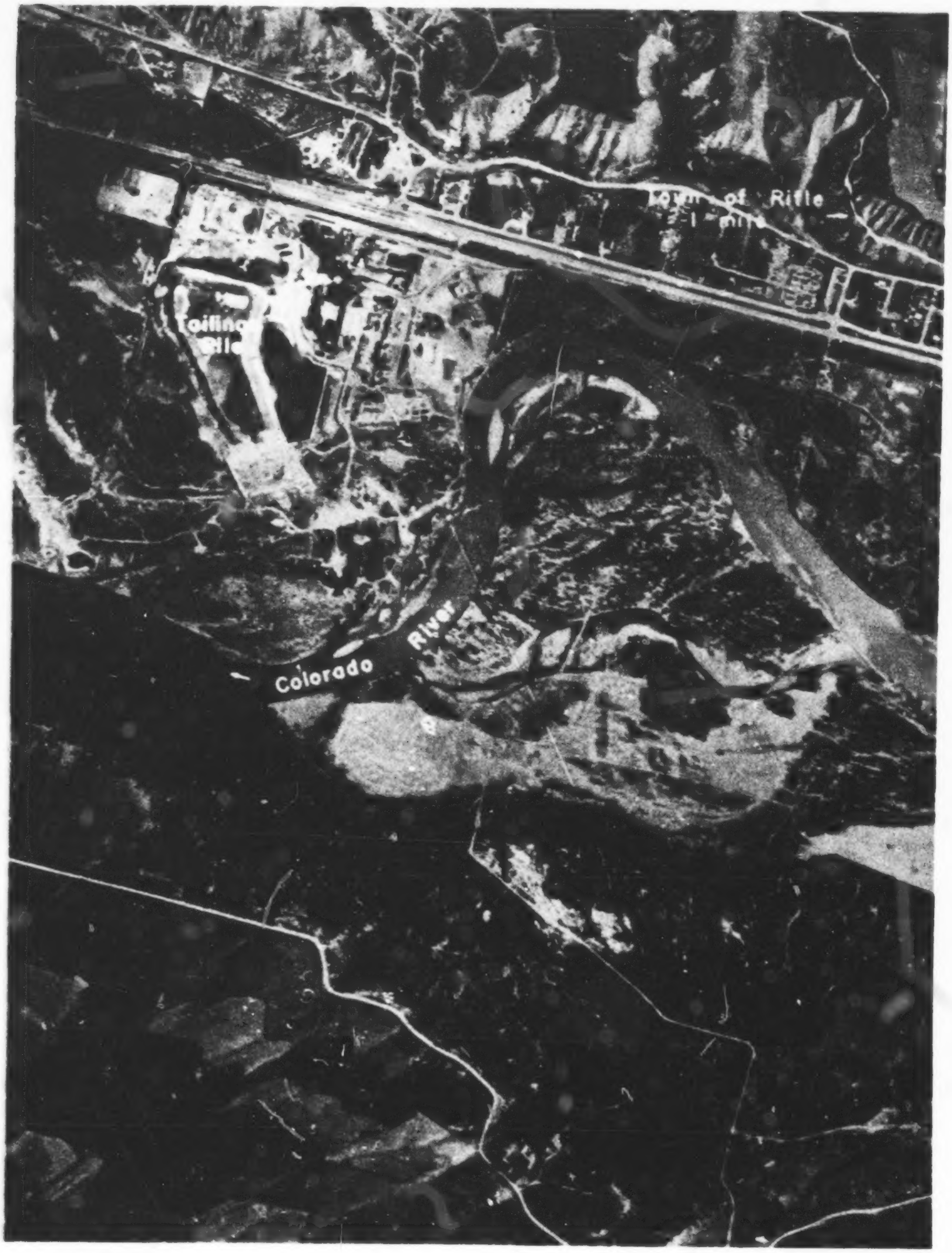
RIFLE (new mill) - Pile location with the Colorado River in the background.

Rifle (new mill) - Operating

The Union Carbide Corporation tailings pile at their new mill southwest of Rifle, Colorado, contains approximately 1 million tons of tailings material. The pile is located on a flood plain of the Colorado River but normal high flows do not reach the pile. The pile is well diked with tailings material and runoff from the surrounding area, or the pile itself, does not cause significant erosion as long as the dikes are maintained.

Wind erosion of the pile has been reported, but the mill maintains some control by wetting the pile with a sprinkler system which seems to be more efficient than the one in use at Durango. If the mill discontinues operation and the pile is allowed to dry, wind erosion may present a problem as well as possible long term erosion from precipitation runoff over the pile.

In the event of mill shutdown, earth covering would be the most desirable control measure, with petroleum product stabilization being a possible alternative.


Town of Rifle
~1 mile
Tailings Pile
Colorado River

RIFLE (new mill) - Union Carbide Corporation

Approximate Scale - one inch equals 1000 feet

URAVAN - Tailings pile locations at the Uravan Mill. Small pile is on the right side of the San Miguel River, and the larger pile on the mesa (upper left).

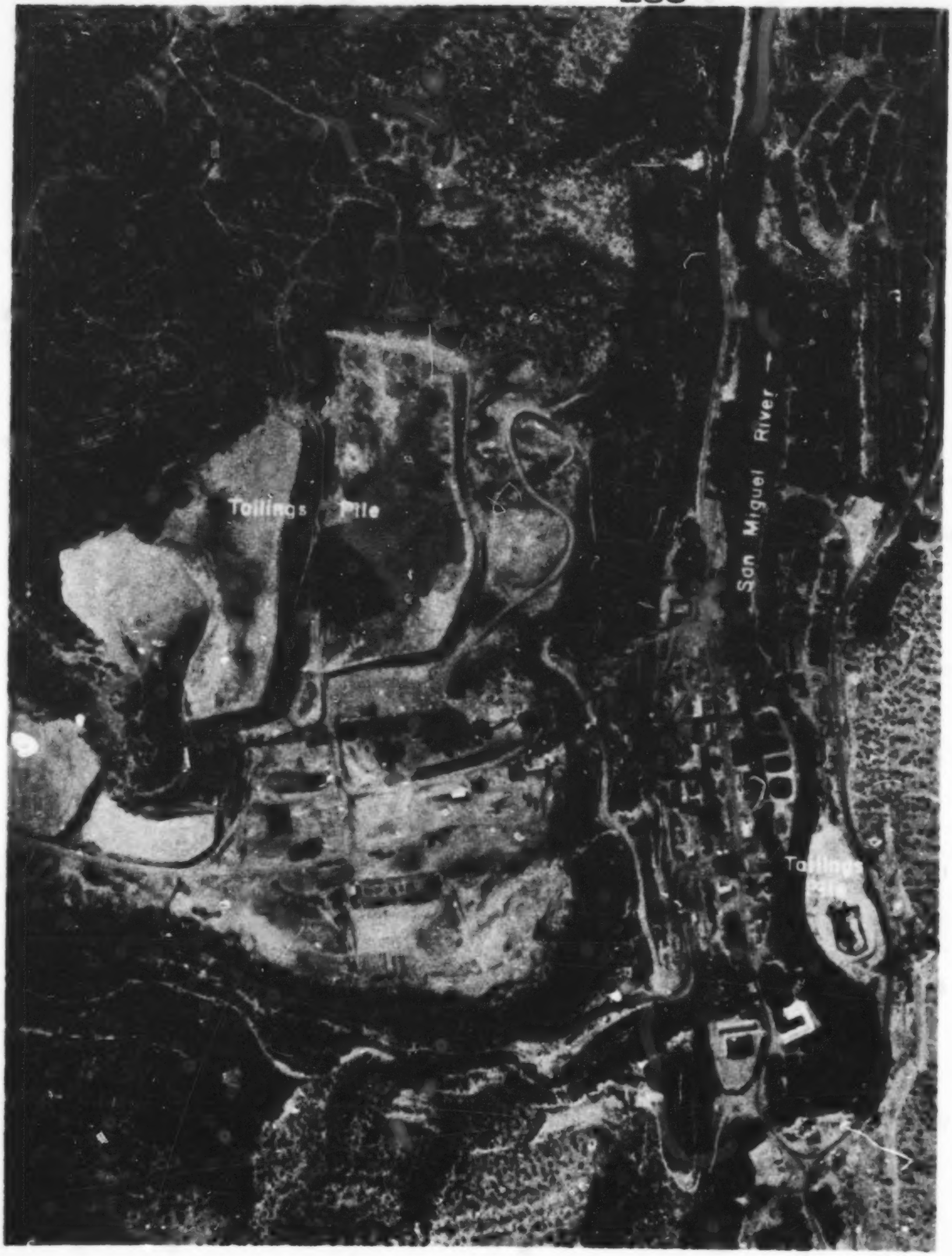
URAVAN - Small pile proximity to the San Miguel River at low flow.

Uravan - Operating

There are approximately 3 million tons of tailings accumulated at the Uravan, Colorado, Union Carbide Corporation mill. Several thousand tons are piled adjacent to the San Miguel River and the remainder is piled on a mesa well above the river.

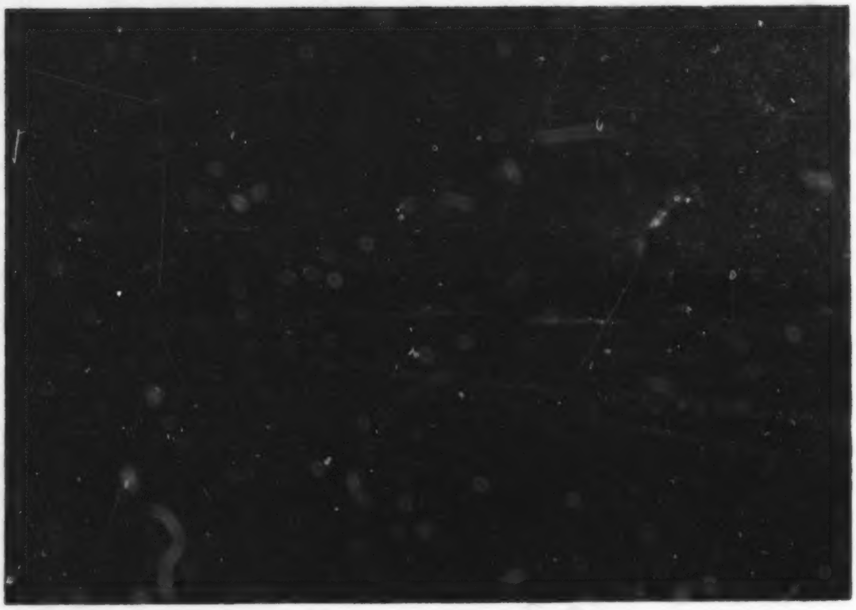
The pile along the river is susceptible to erosion by high river flows, while the pile on the mesa is not significantly affected by either surface runoff or drainage erosion. Air carriage of tailings to the community of Uravan is not visually apparent, but undoubtedly some exists.

Suggested control measures for the pile along the river should be carried out before mill shutdown. Pushing the pile material away from the river's edge and constructing a well riprapped dike should provide adequate control. In the event of mill shutdown, control measures to insure the stability and permanency of the mesa pile should be considered.


Tailings Pile
San Miguel River
Tailings Pile

URAVAN - Union Carbide Corporation

Approximate Scale - one inch equals 500 feet



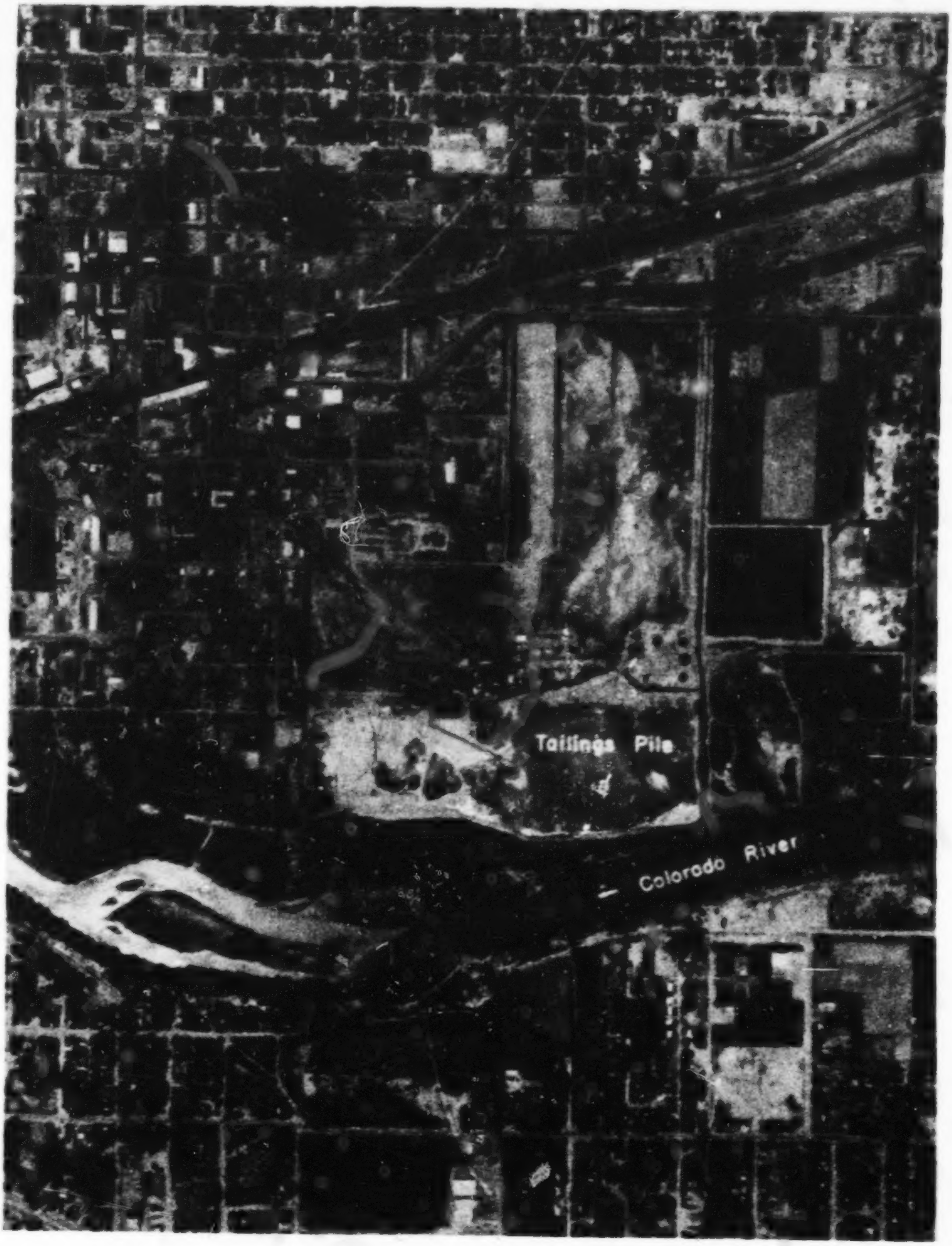
GRAND JUNCTION - Tailings pile and retaining dike proximity to the Colorado River.

Grand Junction - Operating

The Climax Uranium Company uranium mill at Grand Junction, Colorado, is located essentially within the city. The south side of the pile is separated from the Colorado River by a substantial earth dike. Erosion of this dike by the river seems unlikely, unless rather high flows are encountered.

Wind erosion of tailings material to the surrounding community has been noted and would probably tend to increase if the mill discontinued operations and the pile dried out.

Suggested control measures include consideration of either earth or petroleum product covering to prevent wind erosion and insuring dike integrity by placing riprap, as needed.


Tailings Pile
Colorado River

GRAND JUNCTION - Climax Uranium Company

Approximate Scale - one inch equals 1000 feet

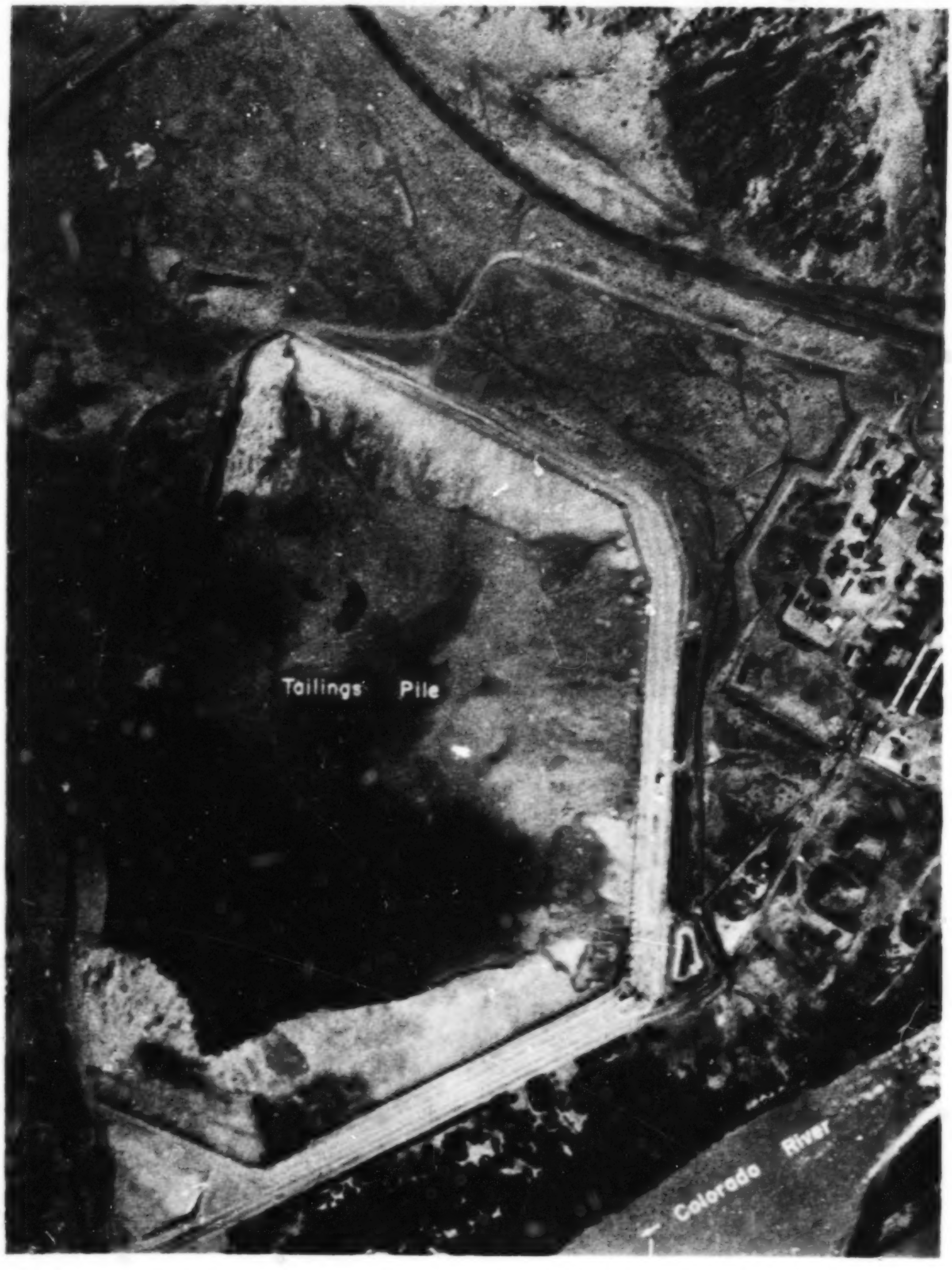
MOAB - General view of the Moab tailings pile. Note the sparse vegetation on the lower portion of the dike at the right. This mill uses an alkaline leach process, which may produce tailings with a pH more conducive to plant growth (see page 25).

Moab - Operating

The Atlas Corporation pile near Moab, Utah, contains over 3 million tons of tailings material and lies near the Colorado River.

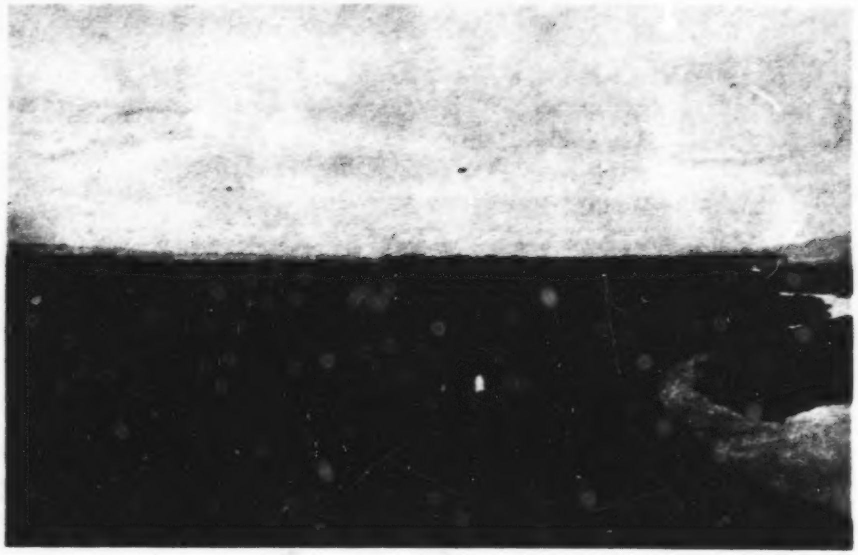
The pile has well constructed tailings material dikes of step design to prevent structural collapse and the low precipitation for this area does not appear to be eroding the pile edges toward the river. A dry wash that is subject to flash flooding runs along the east edge of the pile and has been reported to easily erode the treatment pond dikes in this area. Wind carriage does not appear significant, unless this increases when the surface of the pile dries out after mill shutdown.

Suggested control measures in the event of mill shutdown would be for substantial riprapping along the dry wash and consideration of petroleum product stabilization.


Tailings Pile
Colorado River

MOAB - Atlas Corporation

Approximate Scale - one inch equals 500 feet



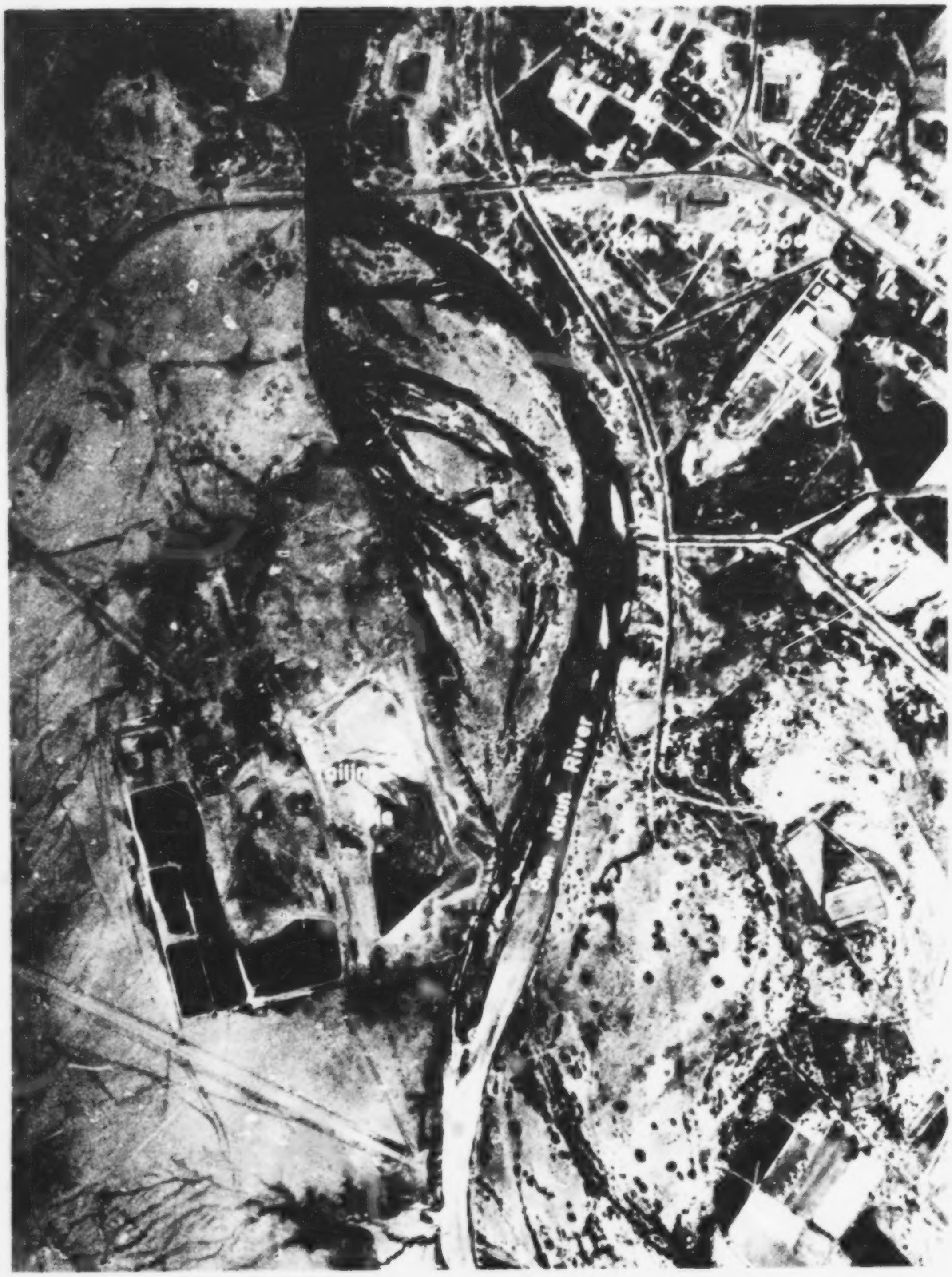
SHIPROCK - An earth reinforced tailings dike (center) keeps this pile several hundred feet away from the San Juan River.

Shiprock - Operating

This pile, located a short distance southwest of Shiprock, New Mexico, is owned by the Vanadium Corporation of America.

The pile rests on a small bluff overlooking the San Juan River and is not susceptible to erosion by either river flows or area runoff. Some wind carriage to nearby Shiprock is probable and some slow erosion to the river of a small amount of tailings from precipitation over a number of years can probably be expected.

Control measures after mill shutdown could include strengthening the tailings pile boundaries by bulldozing more earth up and around them, and blowing could be controlled by a light earth cover or a petroleum product stabilizer.


San Juan River

SHIPROCK - Vanadium Corporation of America

Approximate Scale - one inch equals 1000 feet

APPENDIX B

AEC LICENSING GUIDE

INFORMATION AND CRITERIA PERTINENT TO EVALUATION OF EMBANKMENT RETENTION SYSTEMS

U. S. ATOMIC ENERGY COMMISSION
SOURCE AND SPECIAL NUCLEAR MATERIALS BRANCH
DIVISION OF MATERIALS LICENSING
WASHINGTON, D C. 20545

NOTE

This guide has been complied as an aid in the preparation of applications for source material licenses in which embankment retention systems are employed to prevent or control the release of radioactivity in concentrations exceeding those permitted to be released in 10 CFR 20. This guide is not intended as an interpretation of Commission regulations within the meaning of Section 40.6 of Title 10, Code of Federal Regulations, Part 40. Nothing contained in this guide may be construed as having the force and effect of United States Atomic Energy Commission regulations, nor as indicating that applications for appropriate licensing by the Commission which follow the recommendations of this document necessarily will be approved; nor as relieving any licensee from the requirements of Title 10, Code of Federal Regulations, Parts 20 and 40 or other pertinent regulations.

1. INTRODUCTION

The processing of unrefined source material, particularly the milling of uranium ore, results in the production of large volumes of liquid and solid wastes both of which usually contain concentrations of radioactive material in excess of those which may be released into unrestricted areas under the provisions of Section 20.106, Part 20, Title 10, Code of Federal Regulations, "Standards for Protection Against Radiation". Also, the wastes usually contain chemicals such as acids, alkalies, salts and organics, which could have an adverse effect on the environment if indiscriminately released. It is therefore necessary to contain such wastes so as to prevent or control their release to the environment. Containment may be accomplished by the construction of embankment retention systems. An additional advantage of containment is that it provides storage of solids for possible future reprocessing for other materials and permits the reclamation of liquids for reuse in ore processing.

The size and construction of these retention systems vary with the production capacity of the processing mill, the amount of liquid waste produced, the topography of the area in which the mill is located, and the amount of land available to the mill; for example, these systems may vary in size from a few acres to over 100 acres. Generally, the location of a retention system is selected to take maximum advantage of the natural contour of the area in which it is located, but it is usually necessary at some point to construct an earth and/or tailings embankment to contain the liquid waste. Earth embankments may be constructed for the purpose of retaining only liquid waste or for retaining both solid and liquid waste. In the latter case, the liquid and solid wastes are usually discharged to one area within the system so that the coarse solids continually build up in essentially the same area and the fine solids or slimes and liquids flow toward and are retained by an earth embankment.

Where tailings are used to build or increase the height of embankments, usually one of two techniques is employed - gravity or cyclone separation. When gravity separation is employed, tailings are transported to the retention system as a slurry and discharged near the inside edge of an initial earth embankment. The coarse solids settle out near the initial embankment and the fine solids or slimes and liquids drain to and are retained at the center or rear of the system. When the coarse solid tailings or liquids rise to within a few feet of the top of the embankment, the system is extended or raised by the use of a drag line and/or earth moving equipment. From time to time the embankment may be further raised in the same manner whenever required. In the case of cyclone separation, tailings are also transported to the retention system as a slurry and separated by truck or trestle mounted cyclone separators. Truck mounted cyclones move slowly along the top of the embankment and extend the height of the embankment by depositing the coarse fraction of the tailings along the top and the slimes and liquids well within the retention systems. Trestle mounted cyclones perform the same operations but must be periodically moved along the embankment.

It is important that these embankment retention systems be constructed and maintained in accordance with sound engineering principles in view of their purpose to prevent or control the release of radioactive materials and chemicals to the environment. The Commission has developed criteria for the construction and maintenance of these earth and tailings embankments to be used in connection with the evaluation of the structural integrity and other safety features of these systems prior to the issuance of source material licenses and license renewals.

It is the purpose of this guide to specify information which the Commission will require in connection with the licensing of source material activities involving embankment retention systems. This information pertains primarily to the integrity of the retention system and is in addition to other information normally required by the Commission in support of applications for licenses authorizing milling activities, such as information on local meteorological conditions, geological and hydrological data, effluent survey programs, etc. The purpose of the guide is also to identify the criteria for the construction and maintenance of embankment retention systems that will be used by the Commission in evaluating such systems. The criteria are necessarily general in nature since the characteristics of embankment systems may vary significantly from one location to another. Therefore, conformance with these criteria shall not be considered as relieving an applicant or licensee of his responsibility for assuring that his system is adequate from a structural integrity and radiological safety standpoint.

The Commission may request additional information beyond that specified from applicants or licensees if such information is necessary to provide reasonable assurance that the applicant or licensee has established an adequate system. (See § 40.31(b) of 10 CFR 40.) Such requests may be avoided by a thorough study of Commission regulations and this guide prior to submitting information to the Commission.

An applicant or licensee may incorporate by reference information contained in applications, statements and reports previously filed with the Commission's Division of Materials Licensing, provided that such references are clear and specific. (See § 40.31(e) of 10 CFR 40.) In order to be clear and specific, the aforementioned references must indicate by date, page and paragraph what information the applicant wishes to reference and how such information is applicable to the license application.

2. AUTHORITY

The Atomic Energy Act of 1954, as amended, charges the United States Atomic Energy Commission with, among other things, responsibility for regulating the receipt, possession and use and transfer of source material. The Commission is authorized to establish by rule, regulation or order such standards and instructions to govern the receipt, possession and use of source material as it may deem necessary or desirable to protect health or to minimize danger to life or property.

In the performance of its regulatory functions, the Commission has promulgated the regulations contained in Title 10 of the Code of Federal Regulations. The following regulations are particularly pertinent to the subject of this guide:

1. Part 20, "Standards for Protection Against Radiation".

2. Part 40, "Licensing of Source Material".

Amendments to the regulations are published from time to time in the Federal Register. Current copies of Commission regulations may be obtained from the Division of Materials Licensing, U. S. Atomic Energy Commission, Washington, D. C. 20545, or from any of the following U. S. Atomic Energy Commission Division of Compliance Regional Offices:

Director, Region I
Division of Compliance USAEC
376 Hudson Street
New York, New York 10014

Director, Region II
Division of Compliance, USAEC
50 Seventh Street, Northeast
Atlanta, Georgia 20323

Director, Region III
Division of Compliance, USAEC
Suite 410 Oak Brook Professional
Building
Oak Brook, Illinois 60523

Director, Region IV
Division of Compliance, USAEC
10395 W. Colfax
Denver, Colorado 80215

Director, Region V
Division of Compliance, USAEC
2111 Bancroft Way
Berkeley, California 94704

3. INFORMATION REQUIRED

In addition to the information required by Section 40.31, 10 CFR 40, applications for specific source material licenses which involve the use of embankment retention systems for holding wastes containing radioactive material in concentrations greater than those permitted to be released pursuant to Section 20.106, 10 CFR 20, shall contain the following information as applicable:

A. Drawings showing the layout in plan; typical cross-sections of all embankments showing proposed design, and if applicable, anticipated future extensions; and other pertinent design details. Embankment design should include information on heights, top width, side slopes, freeboard, seepage control, and protection of embankment surfaces as well as foundation design.

B. A design analysis of the integrity of the proposed system including, as applicable, the results of soil tests, geologic exploration, nature of foundation materials, stability investigations and characteristics of fill material as well as a description of the construction methods and specifications.

Reproduced from best available copy.

C. An evaluation and discussion of conditions that might lead to accidental release of the waste, the probable environmental effects of such release, and proposed program of inspection and maintenance to prevent such an accidental occurrence.

4. EMBANKMENT RETENTION SYSTEM CRITERIA

The Commission will take the following factors into consideration in evaluating for approval the information submitted pursuant to Section 3 of this guide:

A. Location

(1) The site should be subject to the control of the licensee so as to permit entry only of authorized personnel thereto.

(2) The site should not occupy the channel of any permanent watercourse unless a provision has been made for permanent diversion of such water course around the site.

(3) The site should be permanently protected against run-off when necessary, from the surrounding drainage area by the provision of diversion channels to prevent such run-off from entering or washing out the embankments.

(4) A minimum distance of 200 feet should be maintained between the embankments and any permanent flowing watercourse at flood stage to minimize percolation effects unless information is submitted for satisfying a closer location.

B. Design

(1) Foundations - Foundations should be investigated to determine that they have suitable strength and permeability characteristics for the embankment proposed, including anticipated future extensions. A foundation of rock or graded sand and gravel is normally considered to have satisfactory strength for small embankments (under 25 feet in height). Foundations of alluvial deposits, which have not been consolidated under appreciable loads, and those of fine and uniform sands or of plastic clays must be given careful investigation and treatment to insure safety of the embankment.

(2) Embankments

(a) Construction material - The embankment material used in the construction of earth embankments may be natural soil, usually borrow soil found nearby, suitable for the construction of such systems. Coarse tailings material may be used to extend an earth embankment during construction of a tailings embankment provided design and construction methods specified in this guide are followed.

(b) Top width - The minimum top width of an embankment should be eight feet. As the height of the embankment increases the top width should be increased as specified in Table I below. It may be necessary to further increase the top width if the embankment material is susceptible to erosion or sloughing.

TABLE I - RECOMMENDED MINIMUM TOP WIDTH FOR EMBANKMENTS

Height of Embankment (feet)	Minimum Top Width (feet)
8 to 12	10
13 to 20	12
21 to 30	15
Over 30	20

(c) Side slopes - In most cases the type of material that is readily available for embankment systems will require that side slopes on the upstream face (i.e., in contact with the liquid) have a slope ratio between 4 to 1 and 2 1/2 to 1 and on the downstream face of the embankment between 3 to 1 and 2 to 1. Table II below contains recommended maximum slopes for embankments constructed of various materials. (For further details of these and other commonly used soil materials, reference is made to the chart, "Unified Soil Classification, Including Identification and Description", adopted by Corps of Engineers and Bureau of Reclamation, January 1952).

TABLE II - RECOMMENDED HORIZONTAL TO VERTICAL SIDE SLOPE RATIOS FOR EMBANKMENTS

Embankment Materials	Upstream Face	Downstream Face
Homogeneous Sandy Clay	2-1/2 to 1	2 to 1
Coarse Sand with compacted clay or structural core wall	3 to 1	2-1/2 to 1
Sand-gravel mixture with compacted clay or structural core wall	3 to 1	2 to 1
Homogeneous Silty Clay	4 to 1	3 to 1
Homogeneous Sandy Loess	3 to 1	3 to 1
Coarse Tailings (dry)	2-1/2 to 1	2 to 1

Where coarse tailings material is used to increase the height of an initial earth embankment, the Commission will consider the material as purely frictional with an angle of internal friction of 33 degrees (i.e., a natural slope of approximately 1-1/2 to 1). This will mean that the downstream face of the embankment should have a total slope ratio of approximately 2 to 1. Berms may be employed in the construction of the embankment to satisfy this side slope ratio, provided the berms are at least eight feet in width, the height of each embankment section does not exceed 18 feet, and the slope of each tailings embankment section is at least the natural slope of the material.

The recommended slopes in the above table may have to be flattened when necessary to spread the load so that the maximum unit stress induced in the foundation will be less than the shear strength of the foundation material or when full knowledge is not available on shear strength and seepage flow.

(d) Freeboard - The freeboard height of the embankment above the maximum liquid level should not be less than three feet. Consideration should be given to future compaction and settlement of the embankment and to frost penetration which would materially effect the possible freezing and cracking of the embankment above water level.

(3) Seepage Control - Suitable methods should be employed to minimize the effect of seepage on the embankment and its foundation. Methods of controlling seepage include toe drains, filter layers, impervious cut-offs or blankets, and corewalls. Seepage along the contact surface between the foundation and the embankment should be minimized

Reproduced from best available copy.

by removal of all organic material such as sod and top soil and where appropriate the installation of a "key" trench.

(4) Protection of Embankment Surfaces - Embankment surfaces should be protected against erosion by the use of such means as vegetation, berms, logs, or riprap. The method of protection used must be based upon the susceptibility to erosion.

(5) Protection Against Environmental Release - Where deemed necessary, provisions such as the use of additional surrounding embankments or sumps should be made for capturing or holding liquid waste resulting from seepage through the embankment or unexpectedly released by failure of the primary embankments.

Unprotected surfaces on the top or within the retention system, such as inadequate crust formation, should be provided with an effective means of dust control, such as a sprinkler system for periodically wetting down these surfaces, a form of cement, asphalt or other binder for a more permanent sealer of the surfaces, or vegetation if found feasible.

C. Construction Methods

Construction of the earth embankment should be started only after clearing and grubbing operations are completed and the foundation has been properly prepared. Embankment material should be free of sod, roots, stones over six inches in diameter, and other material should not be placed in embankments and embankments should not be constructed on frozen foundations. The placing and spreading of embankment material should be started at the lowest part of the section under construction and the embankment carried up in horizontal layers not exceeding eight inches in thickness. Insofar as possible, these layers should be of uniform elevation and extend over the entire area of the fill. The distribution and gradation of materials throughout the embankment should be such that there are no lenses,pockets or streaks created, and the moisture content of the materials should be proportioned for maximum degree of compaction. Proper compaction of the embankment material should be achieved by the use of equipment designed for this purpose, usually a sheepsfoot roller. The travel of excavating equipment is generally not considered an adequate method for obtaining compaction. If the sheepsfoot roller is used, it should be weighted to give a unit pressure of not less than 200 pounds per square inch of the total surface area of the feet simultaneously in contact with the embankment. Usually six passes of the roller over each individual layer of material are sufficient to obtain good compaction. For relatively low embankments, under 25 feet in height, the adequacy of compaction may be determined by observation of the roller in action. For embankments over 25 feet in height, field control over compaction should be more precise and the embankment should be rolled until some predetermined degree of compaction is obtained, usually 90 to 95 percent of maximum density as determined by appropriate compaction tests.

Tailings embankments should be started with an initial [illegible] earth embankment as described previously and may be raised when necessary by using coarse tailings material. The tailings, usually in the form of a slurry, should be deposited within the system in such a way that coarse sands settle out first near the embankment, while the fines or slimes are carried away toward the liquid pond area where the liquid is retained. Observations should be made and records kept of the deposition of tailings as well as sampling of the tailings near the embankment to determine its properties for use in building up the embankment. In order to gain the maximum shear strength from this material, it should have as low a moisture content as possible during embankment extension and all subsequent seepage flow should be minimized. Proper construction methods should be observed as specified above.

D. Maintenance and Inspection

A program of maintenance and inspection should be established to detect and repair environmental and other effects which might tend to lessen the integrity of the embankment system.

APPENDIX C

AGREEMENT

JOINT FEDERAL AGENCY POSITION REGARDING CONTROL OF URANIUM MILL TAILINGS

The Federal Water Pollution Control Administration, the Public Health Service, and the Atomic Energy Commission agree that inactive tailings piles resulting from uranium milling operations should be structurally stabilized and contained to prevent water and wind erosion. Active tailings piles should be managed to minimize such erosion during use.

Planning, management, stabilization and containment of tailings piles are viewed as being the responsibility of the individual mill owners. Mill owners should develop, without undue delay, specific plans for accomplishing such management, stabilization and containment, and submit such plans through the appropriate state regulatory agencies for approval. The staffs of the Federal Water Pollution Control Administration, the Public Health Service, and the Atomic Energy Commission will be available to the state regulatory agencies, upon request, to provide advice and assistance regarding the development of pile stabilization and containment objectives and measures for achieving them.

Compliance by mill owners with approved plans for stabilization and containment should be recognized as constituting fulfillment of mill owner responsibility with regard to such tailings piles. Obtaining and enforcement of tailings piles stabilization and containment plans should rest initially with the states concerned.

General Manager, U. S. Atomic
Energy Commission

Assistant Secretary of Health,
Education, and Welfare

Assistant Secretary of the Interior

December 8, 1966
Date